Edited by Adrian Colston and Franklyn Perring

INSECTS, PLANTS AND SET-ASIDE

ANICAL SOCIETY OF THE BRITISH ISLES

Insects, Plants and Set-aside

Edited by

Adrian Colston and Franklyn Perring

Botanical Society of the British Isles

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Preface

Although the Conference at which the papers in this volume were originally given took place in 1994 it is most appropriate that they should be published in 1995, European Nature Conservation Year. 1995 is a year in which we have all been asked to consider the future of environment and ways in which the forces which have combined to destroy so much of our countryside and its wildlife since European Conservation Year1970 might be reversed. One of those ways, which could have the greatest impact, is to exploit to the full the potential of the advent of set-aside.

The theme of the Conference was to examine the possible effects of the various set-aside options upon plants and insects and their relationships and to try to determine what details of location, management and time-scale are crucial if set-aside is to secure the maximum benefits for wildlife in the countryside within the framework of the needs of the farmers and landowners who care for the land.

Thanks are due to the contributors who gave their minds to the task and produced these timely papers on time: and to the Royal Entomological Society, which generously hosted the Conference and made a financial contribution to the costs of publishing this Report. I would also like to pay tribute to my fellow editor, Adrian Colston, for all his help in creating the publication - integrating the disintegrated - and to Sally Corbet for invaluable entomological advice in bringing the Conference into being.

Franklyn Perring
President, BSBI,
Oundle, March 1995.

Insects, Plants and Set-aside Programme

Royal Entomological Society, 41 Queen's Gate, London, SW7 5HR. 14th April 1994

10.00 - 10.05	Welcome by Dr. Miriam Rothschild F.R.S., President of the Royal Entomological Society
10.05 - 1035	*The Current Options for Set-aside and the Countryside Stewardship Scheme* . Stewart Lane, English Nature, Peterborough
10.45 - 11.10	*The Establishment of Characteristic Grasslands on Set-aside Land: Possibilities in the Short- and Long-term and Implications for Nature Conservation.* Terry Wells, Institute of Terrestrial Ecology, Monks Wood, Huntingdon
11.20 - 11.45	*Arable Weeds and Set-aside - a Cause for Conservation or a Cause for Concern?* L.G. Firbank, Institute of Terrestrial Ecology, Monks Wood, Huntingdon & P.J. Wilson, The Game Conservancy Trust, Fordingbridge
11.55 - 12.20	*Genetic Consequences of Set-aside for Plant Populations and their Implications for Plant and Insect Conservation.* Quentin Kay, School of Biological Sciences, University of Wales, Swansea
12.30 - 13.45	Lunch
13.45 - 14.10	*The Management of Set-aside Land as Brood-rearing Habitats for Gamebirds.* S.J. Moreby & N.W. Sotherton, The Game Conservancy Trust, Fordingbridge
14.20 - 14.45	*Insects, Plants and Succession in Set-aside.* Sarah A. Corbet, Zoology Department, University of Cambridge
14.55 - 15.20	*The Microhabitat in Relation to Insect Populations.* Dr. Jeremy Thomas, Institute of Terrestrial Ecology,Furzebrook
15.30 - 16.00	Tea
16.00 - 17.30	*The Way Ahead* . Panel led by Tim Allen, Countryside Commission, Cheltenham, Dr Sarah Webster, Department of the Environment, Bristol, Richard Knight, Farming and Wildlife Trust and Sarah Hendry,Ministry of Agriculture, Fisheries and Food, London.

The Current Options for Set-aside and the Countryside Stewardship Scheme

Stewart Lane
English Nature, Northminster House, Peterborough, PE1 1UA

Introduction

This paper sets out the current basic framework of set-aside and regeneration options in Countryside Stewardship. The intention is to provide a basis for discussion of specific topics concerning the interaction of insects and plants on set-aside land.

The measures together offer a wide range of management options. Rules on eligibility can be complex as may be the conditions attached to the management options. To cover all this detail is beyond the scope of this paper. On the other hand it is of no small significance that for instance, herbicides can be applied in some options and not others, or that cuttings may or may not be removed. Accordingly this account tries to touch upon all the options and the key conditions attached to them. It also seeks to note the differences between the options and make brief comment on them. The account reflects the situation in England: there are differences in the other UK countries.

The paper deals first with the various types of set-aside, then turns to the regeneration options in Countryside Stewardship, before drawing some brief conclusions. It should be noted that opportunities do exist within certain Environmentally Sensitive Areas to establish wildlife habitats. Likewise in Nitrate Sensitive Areas, options for producing a range of grassland swards are likely to be forthcoming. Neither of these measures are considered in this paper.

Set-aside

Four distinct schemes which have used this name have been or will be operated. These are:

- Set- aside under the Arable Area Payments Scheme
- One year set-aside
- Five year set-aside
- Long-term set-aside under the Agri-Environment Measures, promoted as the Habitat Scheme.

The second of these operated for just one year in 1991, enjoyed only low uptake and merits no further reference here.

Set-aside under the Arable Area Payments Scheme

Introduction

By far the most widespread form of set-aside is that stemming from the Arable Area Payments Scheme (AAPS), which was introduced as part of a series of measures to reform the Common Agricultural Policy. It is at the heart of the commodity regime for arable crops and is administered by the Ministry of Agriculture (MAFF), which provides a detailed description of the measure (MAFF 1993a, b).

It is crucial that the purpose of the measure is understood: it was introduced to reduce arable crop production. Whilst recognising that wildlife, landscape or other benefits might be created through the setting-aside of land, measures that compromise efforts to reduce production will not be accepted. The debate on set-aside and wildlife has thus tended to revolve around how far wildlife benefits can be accommodated into rules and options without threatening production controls.

The AAPS offers per hectare payments on both cereal and land set-aside and replaces payments on the basis of production. It was introduced for the cropping year 1992-93 and its rules are still evolving. In outline the situation for the cropping year 1993-94 is as follows:

The schemes

There are two schemes:

- main scheme: farmers may claim payments on as much relevant land as wished in return for setting land aside.
- simplified scheme: farmers may claim payments on a limited area without setting land aside. The limit in England is 15.51 ha. Accordingly this element is of no relevance to considerations of set-aside.

It is worth adding that if a farmer does not wish to claim payment on his cereal crop there is no need to set land aside but this is unlikely to be financially attractive to many farmers.

The basic rules

There is a complex set of rules. Those with most influence on wildlife include:

- land that was in permanent grass (ie grass over five years old), non-agricultural use or forestry as at 31 December 1991 is not eligible for payment. This docs not mean such land can not be cultivated but if it is, then it will receive no payment. It also means that all land set-aside is ex-arable land.
- the land can not be put to any non-agricultural use that brings a return nor to any agricultural use, save certain non-food crops and winter grazing of the farmers' own animals. This has an important implication for manipulating the sward through grazing.
- the area to be set aside is
    - 15% of the total area on which payments are sought when managed on a rotational basis;
    - 18% when managed on a non-rotational basis or as a mixture of the two.

In this context

- rotational means land set-aside from 15 January to 31 August once every six years. Thus the same land cannot be set-aside during the following five cropping years. Accordingly any wildlife benefits from this system have to be developed and delivered in seven months.
- non-rotational set-aside land must remain set-aside for at least five years and for the full twelve months of the year. In contrast to rotational set-aside, non- rotational set-aside will have five years in which to develop and provide wildlife benefits.
- each individual block of set-aside must be at least 0.3 ha and at least 20m wide.
- the farmer must not damage, destroy or remove specified features on or immediately next to land set-aside. These include hedges, stone walls, rows of trees, watercourses and ponds.
- additional voluntary set-aside above the 15 or 18% level is allowed. However the total area set- aside may not exceed 50% of the total area on which Arable Area Payments (crop and set-aside) are being claimed.

The Management Options and Rules

1. Rotational Set-aside

In considering its potential for wildlife conservation the following quote from the MAFF booklet AR6 (MAFF 1993a) is relevant: "The rules are intended to help ensure that uncropped set-aside is kept in sound agricultural condition, without damaging the environment". In summary the rules are:

- a green cover must be established by natural regeneration or sowing a suitable cover including grass, mustard or mixes of two crop groups (eg cereal and brassica). The options are thus effectively for natural regeneration or a sown sward
- the cover must be cut short by 15 August or destroyed by 31 August. Additional cuts may be made, but this is an extra cost to the farmer.
- fungicides, insecticides and fertiliser must not be applied.
- selective herbicides may be used to control weeds but non-selective herbicides should not be sprayed before 15 April as the cover must remain intact to that date.
- the land may be cultivated after 1 May to control weeds or after 15 July to prepare for the following crop.
- an exemption to any of the rules on environmental grounds may be sought, either in advance for a proposed plan or at the time some circumstance arises. The MAFF literature also outlines how to avoid harming wildlife and refers to some positive actions.

However the acceptance of herbicide use and early cultivation within the short time-frame and on land so used only one year in six, mean that the potential benefits are very modest, as effectively acknowledged in the quote from the MAFF booklet.

2. Non-rotational Set-aside

The relevant MAFF quote is somewhat different:" ..... is kept in sound agricultural condition and that set-aside brings environmental benefit" (MAFF 1993a). There are six options for management, some with variations and mostly well described by their names.

- Field Margins. These must meet minimum requirements for width and area. The cover must be established by natural regeneration or sowing grass seed (of the farmer's choice), and cut at least once per year. Cuttings must not be removed as they would be a form of production. Up to two metres may be left adjacent to a hedge, to allow it to broaden, and a one metre strip left bare to the crop edge.

- Grassland. This requires establishment of a grass cover but the farmer can choose the grass species and include broadleaved species but not certain clover species or lucerne. No extra payment is available for using higher cost seed. The cover must be cut to 10 cm or less between 15 July and 15 August and the cuttings allowed to rot. Up to 10% of any field may be left uncut, the area to be rotated and a two metre strip may be left adjacent to hedges. Exemptions may be sought for cutting at different times or allowing scrub to regenerate and there is scope for managing to more specified objectives, like sandy or damp grassland, though again no supplementary payment is available.

- Natural Regeneration. The aim is to develop a diverse flora from the soil seed bank including some crop volunteers. It is not recommended for heavy soils and those with a long history of intensive management. The land may be cultivated to 7 cm in the first year to encourage germination: in subsequent years such action requires MAFF approval but this may be helpful to arable weeds, insects and birds which use ground with broken cover. The cover must be cut as for grassland.

- Wild Bird Cover. An initial cover of natural regeneration must be replaced in the first spring with a seed mixture of two crop groups. This itself should be replaced with a similar mixture after one or two years during the early spring. The crop must not be cut and fertilisers may be used to help establishment. This option seeks to encourage seed eating birds including wild game birds.

- Non-food Use. A range of annual crops can be grown for processing into specified non-food products. This is an intensive farming process and hardly comparable with uncropped set-aside previously described. Perennial crops that have no food use can also be grown and controls are less onerous. Some options, like short-rotation coppice, may offer wildlife benefits though Woodland Grant Scheme establishment grants can not be used.

- Own Management Plan. Farmers may propose their own plan. Applications to MAFF need to specify objectives and management, and should be supported by an environmental organisation. MAFF literature mentions encouraging ground nesting birds, providing goose feeding areas and otter havens as examples. Providing no Woodland Grant or Farm Woodland Premium monies are paid, woodland establishment should be acceptable. However the lack of such support will probably mean the option is little used.

The general rules for all non-rotational set-aside options are much as given for rotational. However the land may be grazed between 1 September and 14 January - the period of the year when rotational set-aside does not have application - though the sward must be cut to 10 cm beforehand so that growth in the set-aside period is not used.

MAFF provide advice on the potential benefits of the options: field margins to link and extend habitats, natural regeneration for more diverse swards on light land, and so forth. There is also advice on choosing locations, for instance to extend or link existing important areas. This is reflected in the comments and literature of others, such as English Nature (English Nature 1993) and the Royal Society for Nature Conservation (Royal Society for Nature Conservation 1993), and it is reasonable to conclude that non-rotational set-aside offers many more opportunities to produce wildlife benefits than does rotational set-aside.

Discussion

In considering the potential for wildlife on land set-aside under the Arable Area Payments Scheme a few general points merit discussion. Firstly in the 1992-93 cropping year, 501,120 ha were set aside under the measure (Hansard 1994). This is an area almost as big as Northumberland, the sixth largest county in England. Thus a very large area has some potential - perhaps limited - for a positive wildlife purpose. Secondly whatever option is chosen the payment is the same (237 ecu/ha, equivalent to 218/ha on 3 January 1994) and the concept of a single payment level will not change. Management obligations must therefore be reasonably equitable if all options are to be taken up. To ask too much of the manager under a particular option will drive them to seeking a simpler and less demanding one. Finally the preceding discussion has outlined the situation for the cropping year 1993-94. The measures are continuing to evolve and some differences in operation, and possible opportunities are likely for the 1994-95 cropping year. Transfer of obligations between farmers and more flexible rotations of set-aside are under discussion, whilst there is pressure in the UK for land withdrawn from production under forestry or Agri-Environment schemes to count towards set-aside obligations.

Five Year Set -Aside
Introduction

This was introduced by MAFF for the 1988-89 cropping year. It was a voluntary scheme open to farmers who undertook to set-aside at least 20% of their eligible arable area for five years in return for an annual payment. The basic intention was to remove land from arable production but maintain it in a good agricultural condition.

The scheme accepted further entrants for three more years up to the 1991-92 cropping year. At that point the set-aside measure under the Arable Area Payments Scheme was introduced and the scheme closed. Thus the scheme is no longer open but land is still managed under this measure.

The Main Options and Rules

There was a limited range of options, which evolved to some extent during the life of the scheme, as did the rules. The major option was that of fallowing the land, though woodland and non-agricultural use were also options. Fallowing was permitted in three ways:

- Permanent Fallow, when the same area of land was taken out of production for the full five years;
- Rotational Fallow, when the area of land left fallow was moved round the farm;
- Grazed Fallow, when the area was grazed by livestock.

MAFF gave strong encouragement to the permanent fallow option, promoting its greater potential for conservation improvement and for making cost savings, as well as offering higher payment.

The management rules and advice covered similar topics to those already discussed under the Arable Area Set-aside measure. These included:

- a plant cover was to be in place for as much of the period as possible. Suggested plant cover included grass mixtures, with or without clover and including amenity or wildflower mixes, green manure crops, game cover crops and natural regeneration. MAFF advice tended to stress the need for caution with the latter.
- the cover was to be cut twice a year, at least once in July or August. Cuttings could be left or removed. If removed they were not to be fed to animals or sold, and stored in a way to avoid pollution.
- pesticides, insecticides and fungicides were generally prohibited as were fertiliser and organic manure and waste. Herbicides could be used following authorisation from MAFF in specific circumstances.
- the farmer was required not to damage, destroy or neglect environmental features such as hedges, walls, pools, heathland etc on or adjacent to land set-aside.

Discussion

In total nearly 160,000 hectares of land was entered into this scheme in the UK with around 129,000 ha in England. Farmers had an option to withdraw. The total still in the scheme in 1993 the first year of the Arable Area Payment Scheme - was 114,778 hectares, around 22% of that in the AAPS (Hansard 1994).

Just under 80% of the land entered was in the permanent fallow option, with a further 12% in the non-agricultural use category. The counties holding the major concentrations of this land are in the east and central south of England. The future of land in the fallow options is clearly important for flora and fauna which have colonised: opportunities are briefly considered in a later section.

Management conditions have evolved as different set-aside measures have been introduced. For instance the removal of cuttings, often recommended for conservation benefit, was possible under the five year set-aside, but not under the AAPS. It is possible to detect two trends in the evolution of the rules: one to enable wildlife benefits to be achieved and one to ensure compliance with tight European rules disallowing any production. Sometimes these pull in opposite directions and resolution reflects the fundamental reason for the existence of the scheme under consideration.

The top-up: Countryside Premium

Introduction

In order to achieve environmental and recreational objectives on the five year set-aside land, the Countryside Commission (CC) launched the Countryside Premium (CP) as an experimental scheme in June 1989. Land was accepted into Countryside Premium for the 1989-90 crop year through to the 1991-92 crop year, ie the last three in which applications were accepted in the five year set-aside scheme. It was intended that the set-aside and CP agreements would run concurrently on individual farms. Many agreements were for five years and though the scheme closed to new entrants when the five year set-aside scheme ended, the most recent agreements could run until September 1996.

The scheme provides annual payments to farmers for positive management of set-aside land to benefit wildlife, the landscape and the local community (through providing access). A range of capital work payments were available in the first year of the agreements.

The main rules

Those which are most relevant to wildlife considerations include:

- its availability in only seven counties in eastern England: Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Norfolk, Northamptonshire, Suffolk.
- not all CP options could be applied to every set-aside option. In practice Permanent Fallow offered the most possibilities and in the event little other land was put forward.
- the MAFF set-aside rules still applied.
- there was no overall limit on the area of land which could be accepted into the CP scheme.
- the scheme was discretionary. The Countryside Commission retained the right to refuse inappropriate applications, though alterations would be discussed. In this important respect it differed from the five year set-aside scheme (and set-aside under the current AAPS) where, if the requirements of the scheme were met, the application would be accepted.

The options

The options with their objectives were:

- Wooded Margins: To manage existing hedgerows and field margins to create valuable habitats for wildlife, and to create new hedgerows and belts of broadleaved trees and shrubs.
- Meadowland: To create new areas of grassland for quiet countryside enjoyment by the local community and for the benefit of wildlife.
- Wildlife Fallow: To create a habitat attractive to ground nesting birds and encourage the growth of wildflowers on arable land by allowing controlled growth of natural vegetation on light free draining soils.
- Brent Geese Pasture: To create winter grazing for Brent Geese in selected areas as a means of minimising grazing damage to winter cereal crops elsewhere.
- Habitat Restoration: To restore certain valuable wildlife habitats. (In practice this comprised a limited number of sites spanning a range of grassland types plus wetland, heathland and parkland.)

Discussion

The Countryside Commission have published a report on the achievements of CP in its first three years (Countryside Commission 1993a). The findings which have most relevance to the development of set-aside schemes and provision for nature conservation include:

- CP is capable of delivering significant wildlife benefits beyond the five year set-aside scheme.
- the integration of capital items with incentive payments was important.
- three factors tended to militate against the creation of herb-rich swards (which is relevant to three of the options). These were high nutrient levels of soil, the leaving of cuttings on site and the short time-span of agreements.
- compliance with the agreed prescriptions had been poor on occasions. It was suggested this could be improved by providing better guidance to farmers, including an idea of the results for which they should be aiming. This is an important element in all set-aside measures: how can farmers be helped to understand better what is being sought in terms of benefit to wildlife?

The future of land in CP, and also in five year set-aside without the CP top-up, is important. Where wildlife interest has developed, opportunities should exist to safeguard and enhance that value. There are two possibilities for land coming out of five year set-aside: the Habitat Scheme (described in the next section) and Non-rotational Set-aside. Although the latter has already been discussed, there are some relevant additional rules and indeed opportunities. These are:

- all five year set-aside land can remain set-aside. There will be an exemption from the 'cropped area' limit (ie that the area of set-aside must not exceed the cropped area on which payment is made).
- land above the cropped area limit will be paid at a lower rate, around two-thirds of the full rate. This means that for instance, where there is no cropped land, all the ex-five year set-aside will be paid at the lower rate.
- land set-aside in excess of the cropped area limit must not have been cultivated between the end of the five-year agreement and being set-aside under AAPS. However there will be special transitional arrangements for land coming out of the five year scheme in September 1993, allowing it back into set-aside in the 1994-95 crop year, even if cultivated for the 1994 harvest.

The implication of these complex transitional arrangements and tiered payments are not yet clear. In any case it must be kept clearly in mind that the Habitat Scheme and AAPS provide voluntary options for farmers to make use of if they choose. Land coming out of the five year scheme can be recultivated if so wished.

The Habitat Scheme

Introduction

The Habitat Scheme has its origin in the 'Agri-Environment' proposals agreed by the European Commission (EC) in 1992 (Council Regulation EEC No 2078/92). That package contained a range of measures which national governments could utilise in order to create environmental benefits through the farming system. Included were provisions for extensifying crop production, reducing the use of fertilisers and plant protection products, keeping up abandoned farmland as well as one "to set aside farmland for at least 20 years with a view to its use for purposes connected with the environment". The use of the word 'farmland' should enable land other than arable to be covered by this long term set-aside option.

MAFF drafted a range of schemes from these provisions, including the Habitat Scheme produced from that for 20 year set-aside, and consulted upon them in March 1993 (MAFF 1993c). Following this, schemes for England, Scotland and Wales were finalised and put to the EC in the following August for approval, with some details given in a MAFF press release (MAFF 1993d).

The Options

The final detailed format of the Habitat Scheme has not yet been announced as its approval (as part of the UK's submission) was still awaited from the EC at the end of March 1994. The options and details that are known or can be surmised are:

- Intertidal Habitats: This would probably be available nationally on both arable and permanent grassland and would seek the creation of salt-marsh in particular. Reflecting the title of the whole scheme, this option is likely to be targeted at locations where clear wildlife benefits should be achieved. The novel nature of the scheme, allowing salt-water inundation onto farmland, will almost certainly mean take up is slow. It is however an important element of a coastal conservation policy.
- Water Fringe Habitats: Again this is likely to be available on arable and permanent grassland but targeted on deemed water bodies, possibly of high nature conservation value, rather than being available nationally. The details given in August 1993 (MAFF 1993d) identified seven sections of river or water-body as being covered by this option. These included parts of the Wiltshire Avon, the Beult in Kent, the Derwent in Yorkshire and four Shropshire meres. The objective of the option is likely to be to protect the aquatic flora and fauna by reducing run-off and to create a rich wildlife habitat on the waterside banks. Unlike the Intertidal option, grazing would be a very valuable management option but it is not clear whether this will be possible or whether previously grazed land could be accepted.
- Five Year Set-Aside Carry-over: Particularly valuable habitats which have developed on five year set-aside land could be carried over into this option. Just how this will operate is not clear at present. Since a range of habitats and features will have developed through set-aside management, with or without the various Countryside Premium options, an assessment process may well be necessary since some land will doubtless have more value or potential than other land. From this the eligible sites may become divided into a number of management options or an individual plan could be required. Land which does not hold any particularly valuable habitat may be directed into the non-rotational element of AAPS.
- Lowland Heath and Lowland Damp Grassland: These were two further possibilities announced by MAFF in April 1993. However these were only to be promoted if the EC rules allowed land placed in these options to count as set-aside under the AAPS. At present it seems unlikely that this will be allowed, as with the woodland issue noted earlier, so that these options are very unlikely to be promoted, at least in the short term.

Discussion

This scheme has much potential but its shape, let alone details of management and likelihood of success, is still very speculative. An announcement in the second quarter of 1994 on its implementation is likely. Its origin and development do however show that it is quite different from all other 'set-aside' schemes in that its purpose is environmental benefit and not control of arable produce.

Countryside Stewardship

Introduction

Countryside Stewardship (CS) was introduced in 1991 as a five year pilot project seeking to develop a flexible, nationwide system offering incentives to land managers to improve the countryside and opportunities to enjoy it.

It does this through ten year management agreements which seek to achieve one or more of the following objectives:

- to restore and conserve the special qualities of a range of landscape types,
- to conserve, improve or restore their wildlife habitats.
- to conserve and restore important historical features.
- where appropriate, to create or improve opportunities for people to enjoy those landscapes, habitats or features.

It is run by the Countryside Commission in partnership with English Nature and English Heritage and fully described in the CS Handbook, revised annually. The following account is based on that produced for applicants in 1993 (Countryside Commission 1993b).

A distinctive feature of the scheme is its selective approach: the CC will only accept applications that offer positive environmental or recreational benefits and good value for money. It is a voluntary scheme, open to anyone who can enter the required agreement, including tenants, owners, local authorities and voluntary bodies.

The Options

CS operates on the following English landscapes:

- chalk and limestone grasslands
- lowland heath
- waterside landscapes
- coastal land
- uplands
- historic landscapes and old orchards
- the old meadows and pasture of the Culm in Devon and Cornwall, and of Hereford and Worcester.

The way in which CS seeks to operate on chalk and limestone grassland is illustrative of how it aims to meet its broad objectives. Here the scheme targets:

- existing pastures where a change in management is needed to conserve or enhance landscape, wildlife or archaeological remains.
- conversion of cultivated land to permanent pasture on low yielding soils through natural regeneration or re-seeding, in order to extend or restore landscape, wildlife habitats or historic landscapes.
- areas of historic remains needing active measures for their conservation.
- opportunities for people to enjoy these features.

The scope of CS is clearly very much wider than the regeneration of habitats and wildlife features on arable land, but it is this aspect which has a particular relationship to set-aside. The element that relates to conversion of cultivated land in chalk and limestone landscapes is similarly represented in all other landscape target areas except the old meadows and pasture option. The elements are:

- Lowland Heath: re-creation of heath on cultivated land or forestry land where soil conditions and location are suitable, particularly where this will link or extend existing heaths.
- Waterside Landscapes: conversion of cultivated land to permanent grassland, to extend habitats and create waterside landscapes and features, such as fens, carrs and reedbeds.

- Coastal Land: regeneration of flower-rich pastures and other semi-natural coastal vegetation on cultivated land along the coastal fringe to improve the landscape and extend or increase wildlife habitats and diversity.
- Uplands: conversion of suitable agriculturally improved land to moorland, particularly where this will restore former boundaries between moor and in-bye.
- Historic Landscapes: the conversion of cultivated land to permanent grassland or other appropriate vegetation cover to protect important historic features.

These regenerative targets become re-ordered into the following specific measures offered under CS, each with a specific code and annual payment level:

- regeneration of grassland or other semi-natural vegetation.
- regeneration of diverse chalk or limestone grassland.
- creation of permanent grass margins, at least six metres wide.
- re-creation of heathland on cultivated or forestry land.
- restoration of moorland vegetation on improved land.

Both grassland and heathland measures have further options comprising a supplementary payment for additional, initial measures.

Management Guidelines and Rules

The CS Handbook (CC 1993b) sets out principles that apply to all agreement land, plus guidelines for each option. However the CC encourages farmers and land managers to use their own skills and knowledge to help meet environmental objectives. For that reason standard practices are not imposed where acceptable alternatives or local traditions are operated which can meet the same end. Whilst this opens up opportunities for dealing with land management problems, it can also present challenges in judging the appropriateness of the proposal.

The principles applying to all CS agreements are similar to those noted in other schemes, in particular:

- no fertilisers.
- limited herbicide use.
- no ploughing, modification to drainage systems or supplementary feeding (unless specially agreed).
- ensure any essential rolling or harrowing avoids disturbance.
- manage grazing to avoid damage to the sward.
- maintain rights of way.
- protect other features on the holding.

There are additional guidelines applying to each of the specific regeneration measures. Two examples are given; details of the others are in the CS Handbook (CC 1993b).

To regenerate grassland, including chalk and limestone grassland, on cultivated land the additional guidelines state:

- the land must have been cultivated before 1 January 1990.
- establishment should be achieved by natural regeneration where possible.
- the sward should be managed by careful grazing, with or without haymaking.
- where soil fertility is high, measures should be taken to reduce soil fertility.
- where natural regeneration is not appropriate, seed should consist of four species, appropriate to locality and soils from a given list.
- seeds should be of British origin.

The supplement for additional measures covers activities such as spreading hay from local herb-rich grassland or taking measures to reduce soil nutrient levels.

The options on the management of existing heath and re-creation of lowland heath both require the production of a ten year management plan. For the latter option, advice is given on selecting suitable sites while plans should include interpretation of soil tests and a suitable combination of:

- light cultivation in spring of the first year to encourage regeneration,
- thereafter, cutting outside the nesting season, with removal of cuttings, or
- carefully regulated grazing.

The supplement for additional measures covers actions like clearing deep bracken litter and spreading heather cuttings containing seed. It is also available for initial steps taken to reduce fertility and measures to control invasive species without inhibiting heather seedlings.

Discussion

A number of significant points are demonstrated by CS:

- it is a pilot: it is experimental, it has evolved and the results should inform successor schemes.
- the primary purpose is environmental conservation: restraint of production of land coming out of arable is a by-product.
- prescription is limited and the scheme encourages land managers to contribute their experience to achieving the right management, thereby increasing their commitment to its success.
- it is selective: limiting management prescriptions and seeking the ideas of land managers inevitably places increased responsibility on CS officers in evaluating applications.
- CS has a major objective in supporting management of existing habitats as well as one of regenerating habitats and features of value. In that respect it is a wide-ranging measure, more in common with Environmentally Sensitive Areas than set-aside mechanisms.

During the first three years, a total of 2,963 agreements were completed covering 80,174 ha (Countryside Commission 1994). Only a minority of this will be under a regeneration option and the figure will be small compared with existing set-aside schemes. However the CS regeneration options have more closely defined conservation objectives, as well as being within a scheme which sustains existing habitats.

General conclusions

This paper has sought to provide a basis for discussion of specific topics concerning the interaction of insects and plants on set-aside land. For those promoting wildlife conservation, much recent activity has focused on ways of producing and maximising opportunities for such species on land being set aside, and coming out of arable production more generally.

A number of schemes have come forward and these have been briefly outlined. All have distinctive characteristics, opportunities and limitations, financial and of the experience that time brings at the very least. Some of the underlying issues arising from a consideration of the current schemes are:

- the basic objective of the scheme: is it for production control or for environmental purposes? This has a crucial influence on what options are available and what management techniques can be accepted.
- the management feasibility: can it be agreed that the desired operations are truly practical? The measure stands little chance of success if policy makers and farmers can not understand its intentions or agree that they are achievable.
- the cost: what element, if any, of costs can the land manager be expected to absorb? The relationship between type and level of payments and of undertakings is critical. To enjoy public support, good value for money needs to be clearly shown.
- integration: is the relationship between set-aside measures, other countryside schemes and farming support clear enough? To achieve conservation benefits and public endorsement, the land being set-aside and its management should be related to the management opportunities on the farm and the requirements of the wildlife in that region.

These measures will doubtless evolve and others come forward. All will benefit from a better understanding of the interaction of insects, plants and other wildlife with set- aside land.

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The Establishment of Characteristic Grasslands on Set-aside Land: Possibilities in the Short- and Long-term and Implications for Nature Conservation

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Introduction

The EC set-aside scheme which came into operation in the United Kingdom in July 1988 was a voluntary scheme which had been designed with one objective, namely to reduce surpluses of arable crops. The scheme came in for severe criticism from those interested in wildlife conservation because the management prescriptions seemed unlikely to allow the development of a diverse flora and flora. Set-aside land could be rotated annually or remain in the same place for five years. Set-aside land had to be managed within defined conditions which included a requirement to establish a green plant cover, or if the previous crop was in cereals or grass, natural regeneration was permitted. There were also rules regarding the number of cuts which the vegetation was required to be given and when these should be applied. All of these prescriptions had one main aim which was to enable set-aside land to be converted back into a traditional farming system when the time came or a need arose.

Plant communities which develop on set-aside land

In ecological terms, set-aside is a form of secondary succession which occurs when land is abandoned and has been referred to as old-field succession in the USA. It has been the subject of frequent study over the last three decades in America but has received less attention in Europe, although the studies of abandoned fields in Bohemia (Osbornova, Kovarova, Leps and Prach 1990) go some way to redress the balance. The results from these studies suggest that a whole range of factors influence the type of vegetation that develops when arable fields are abandoned. These include: soil type, soil fertility, previous cropping history, previous field cultivation and herbicide usage, the character of the surrounding landscape, the nearness of plant propagules and their powers of dispersal, and the influence which grazing animals may have on the course the sere takes. It is both difficult and dangerous to generalise about the outcome of these many factors on successional processes, but the following general points arise from the numerous surveys and studies that have already been made on British set-aside, which are of relevance to the development of grasslands:

- In the first year, the vegetation is dominated by volunteer cereals, annual grasses (such as *Bromus sterilis, Alopecurus myosuroides* and *Poa annua*) and annual dicotyledonous weeds (forbs) such as *Galium aparine, Picris echioides* and *Stellaria media.*

- In the second year, there is a decrease in annual weeds and an increase in perennial grasses, especially of *Agropyron repens*; perennial weeds such as *Cirsium arvense* and *Cirsium vulgare* and various dock species also generally increase.

- In years three to five, the proportion of grasses usually increases, partly as *Agropyron repens* spreads and partly as other perennial grasses, such as *Arrhenatherum elatius* and *Poa trivialis,* increase. Thistles, docks and sow-thistles (*Sonchus* spp.) predominate among the forbs. Other 'weed' forbs, such as *Potentilla reptans* and *Glechoma hederacea,* may also increase and on some sites agricultural legumes such as *Trifolium repens* may be frequent locally .

- Management (cutting) may alter the relative frequencies of the species discussed above and create new niches for colonisation, but in general, the species composition remains much the same.

- 'Desirable' species, and especially those characteristic of species-rich permanent grasslands, are conspicuous by their absence. These species do not have long-lived seed banks and many are slow to colonise from existing grasslands. On many farms, remnants of such grasslands are no longer found and the opportunity for re-colonisation no longer exists.

The only practical way of establishing attractive or species-rich grasslands on set-aside land on many farms in lowland Britain is to sow grass/forb mixtures appropriate for the site conditions. As the prospect of 20 year set-aside becomes more likely, the environmental benefits which may accrue from sowing attractive grasslands increase; there are also likely to be significant benefits to wildlife on five year set-aside land managed on a non-rotational basis. The remainder of this paper is concerned with exploring the results from two long term experiments which have attempted to establish such grasslands on a clay and chalk soil respectively.

Establishment of a wildflower grassland on heavy clay soil.

The full details of this experiment are given in Wells (1978) and only a brief resume will be given here.

Eight seed mixtures and a control (no seed sown) were established on a heavy clay soil at Monks Wood in June 1978. A randomised block layout with four replicates was used. Plot size was 10 square metres. Details of the composition of each mixture are given in Tables 1 and 2. The three 'short herb' mixtures contained 10 forbs, the three 'tall herb' mixtures 13 forbs. Each of these mixtures were sown with different cultivars of *Festuca rubra* or a mixture of 4 'native grasses' (*Alopecurus pratensis, Briza media, Hordeum secalinum* and *Trisetum flavescens)* to see if grasses of different growth forms and habit influenced the establishment and performance of the forbs. Two commercially available wild - flower mixtures were also sown for comparison. All mixtures were sown with a nurse crop of Westerwolds rye-grass (at 4.6g m^{2}) to provide a rapidly established green cover. Mixtures were sown at between 2.4 and 3.45g m^{2}. All plots were managed by cutting once a year in early August, with the cut material being removed.

Detailed results from the first 3 years of this experiment are given in Wells (1983). The most important points to emerge were:

- Westerwolds rye-grass was the most abundant species for the first 12 months after sowing and persisted in small quantity for one year but had disappeared from most plots by 1980.

- In both short and tall herb mixtures, *Lotus corniculatus* was the most abundant herb and accounted for over 50% of the total above ground biomass until 1984. It was the only non-native forb used in this trial and proved to be a highly competitive cultivar, beginning growth early in the year and forming a substantial canopy before other species had begun growth.

- *Leucanthemum vulgare*, although not producing large quantities of plant material, was the most prominent forb during 1979 and 1980, but was much reduced in 1981 and in years thereafter.

- Nine of the 10 sown forbs in the short herb mixture established (*Rhinanthus minor* failed to germinate, old seed) but *Anthyllis* and *Medicago lupulina*, while providing colour in the first and second years after sowing, were short-lived and made little contribution after 1979. *Galium verum, Leontodon hispidus, Plantago media, Primula veris* and *Prunella vulgaris* all provided colour to the plots at different times of the year.

- All 13 of the sown forbs in the tall herb mixture established, but *Filipendula vulgaris, Geranium pratense* and *Silaum silaus* were thinly scattered in the plots and did not reach flowering size until they were at least 4 years old. *Centaurea nigra* gradually increased in abundance with time and became the dominant 'tall herb' in all plots in which it was sown. It has also invaded some of the other plots.

- Although the number of unsown species (originating from the soil seed bank) in the sown plots varied from 10 to 18, with the exception of *Trifolium repens*, they were quantitatively unimportant after the first year, and by 1981, their average contribution to the total biomass was less than 5%.

- In the unsown plots, 24 forbs and 10 grasses were recorded from 1979-1981. *Trifolium repens* was particularly abundant during the first year, gradually being replaced by grasses such as *Agrostis stolonifera, Phleum pratense* and *Holcus lanatus*. Over time, the control plots have gradually been colonised by other species, but are still, after 15 years, distinguishable from the sown plots.

- In the mixture containing 'native' grasses, *Trisetum flavescens* was initially most successful, but was less so in the period 1986-89, when *Alopecurus pratensis* performed better in the wet conditions. *Hordeum secalinum* forms very little leaf material and although seen every year has never been abundant. *Briza media* established in small quantity in a few plots but has never made a significant contribution to the appearance of the plots.

- Both cultivars of *Festuca rubra*, 'Cascade' and 'Rapid', established well and formed a substantial understorey in the vegetation. The tufted cultivar 'Cascade' consistently out-yielded the rhizomatous cultivar 'Rapid', forming a turf among the forbs. However, both cultivars were largely replaced by other unsown grasses during the wet years of 1986-88, which performed better under those conditions.

- The mixtures obtained as 'wildflower mixtures' from two seed merchants contained high proportions of agricultural grasses and forbs (especially *Trifolium pratense)* which did well for the first two years but were gradually replaced by other species. Only *Achillea millefolium* and *Plantago lanceolata* survived from the original mixtures.

The fate of groups of species (sown grasses, sown forbs, unsown grasses, unsown forbs) and changes in the amounts of litter, moss and undetermined plant material (miscellaneous) from 1979 to 1991 in representative treatments, are shown in Figures 1 and 2. These graphs illustrate the fluctuating fortunes of groups of species which are probably related to changes in environmental conditions from year to year, dry years favouring some species, wet years others. The dramatic effect which two successive wet winters can have on species is illustrated by the tremendous decline in *Lotus corniculatus* (which made a major contribution to the sown forb class) which occurred following the extremely wet winters of 1986 and 1987. Conversely, *Alopecurus pratensis* increased in the same period.

Overall, unsown grasses, especially *Holcus lanatus* and *Agrostis stolonifera*, have increased over the past 5 years but the effect has not been evenly spread across all treatments indicating that some mixtures are more competitive and resistant to the ingress of 'weed' grasses than others. For example, *Holcus* and *Agrostis stolonifera* increased greatly in plots containing cultivars of *Festuca* but have not increased in plots containing a mixture of sown native grasses.

The behaviour of individual species over the period 1978 to 1991 can for convenience be classified as follows:

(a) Species which established and did well in the first 2 years, but disappeared in later years

Anthyllis vulneraria, Bellis perennis, Centaurea scabiosa, Daucus carota, Medicago lupulina, Melandrium album, Pastinaca sativa, Sanguisorba minor, Trifolium pratense and Westerwolds rye-grass.

(b) Species which did well initially, then declined but remained at a low level of abundance

Hypochoeris radicata, Lotus corniculatus, Plantago media, Prunella vulgaris.

(c) Species which have mostly increased with time

Centaurea nigra, Filipendula vulgaris, Leontodon hispidus, Ranunculus acris, Silaum silaus.

(d) Species which have appeared late in the succession

Rhinanthus minor did not establish from seed sown in 1978 (probably because two year-old seed was used), but it spread into the plots in 1989 from a nearby seed source and by 1991 accounted for 7 to 23% of the above ground biomass.

(e) Species which appeared to fluctuate randomly

Achillea millefolium, Galium verum, Geranium pratense, Leucanthemum vulgare, Plantago lanceolata, Primula veris.

(f) Grasses

- *Festuca rubra* (Rapid). Sown in treatments 2 and 5. Increased to a maximum of 6-8% in 1981-82 but fell to <1% from 1984-89. In 1991, increased in treatment 2 to 5% but remained at about 1% in treatment 5.

- *Festuca rubra* (Highlight). Sown in treatment 4. Grew quickly and accounted for 11% in 1980, 12% in 1981 and 7% in 1982 but fell thereafter to low levels in 1984. Recovered to some extent thereafter, but never contributed more than 6% to the total above ground dry weight.

- *Festuca rubra* (Cascade). Sown in treatments 7 and 9. Increased linearly to a peak of 10-13% in 1981, and fell thereafter to <6%.

- *Trisetum flavescens*. Sown in treatments 3 and 6, but invaded other plots from 1980 onwards. In plots in which it was sown, it increased from 2.5% in 1979 to a peak of 20-25% in 1981, fell to c. 3% in 1984 and has remained at between 2.5 and 5% since then.

- *Alopecurus pratensis*. Sown in treatments 3 and 6. In both treatments it increased steadily from 3% in 1979, to c.10% in 1982, c.20-23% in 1984 reaching a peak of nearly 50% in treatment 3 in 1988 and c.35% in treatment 6 in 1988. In 1991, these values had fallen to 34 and 17.5 respectively. It spread into other plots by seed from 1982 onwards and in 1991 accounted for up to 10% of above ground biomass in some plots.

- *Hordeum secalinum*. Sown in treatments 3 and 6. Never present in any great quantity and reached a peak contribution of 6.5% in treatment 3 and 1% in treatment 6 in 1985. It has only invaded one other plot (treatment 9).

- *Lolium perenne*. Only sown in treatment 8, where it reached a peak of 12.5% in 1980. This species has also seeded into other plots.

- *Phleum pratense*. Only sown in treatment 8 but used in the guard rows and seeded from these into some of the plots. However, present in only small quantity in all plots except for treatment 8 in which it accounted for 17.5% of the biomass in 1981. By 1991 it contributed less than 1% to any plot.

- *Agrostis tenuis*. Sown in treatments 8 and 9. In treatment 8, it accounted for 20% of total biomass in 1981-82, but this decreased with time and presently is found in only small quantity in any plot. This species has not spread to other plots.

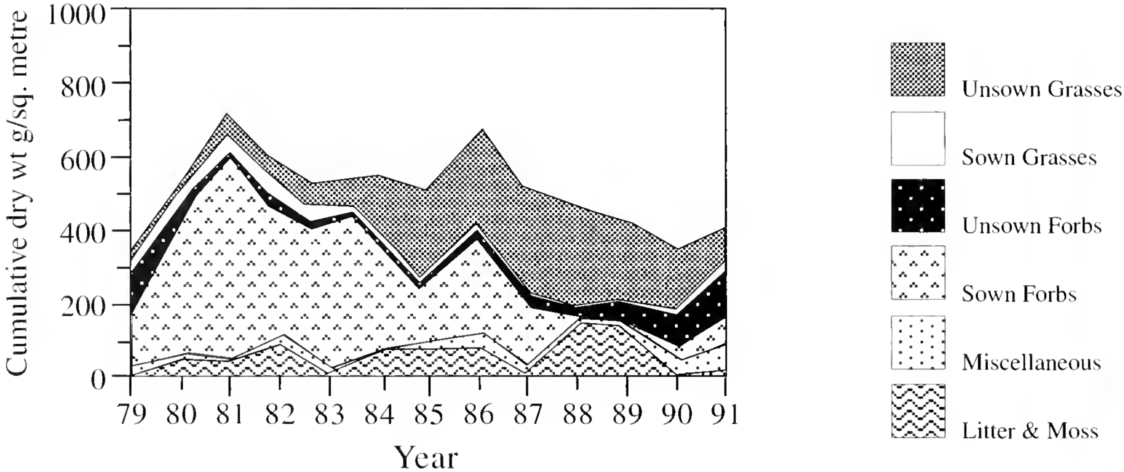
- *Poa pratensis*. Only sown in treatment 9 as the cultivar 'Baron'. Has never done well and although it spread by seed to other plots it is only present in very small quantity.

- *Cynosurus cristatus*. Only sown in treatment 9, where it gradually increased and accounted for 20% of biomass in 1981, 7% in 1982 and 15.5% in 1984. Has seeded into all plots but its contribution to total biomass is small.

Monks Wood: Herb-rich Grassland Restoration Trails 1979 -1991

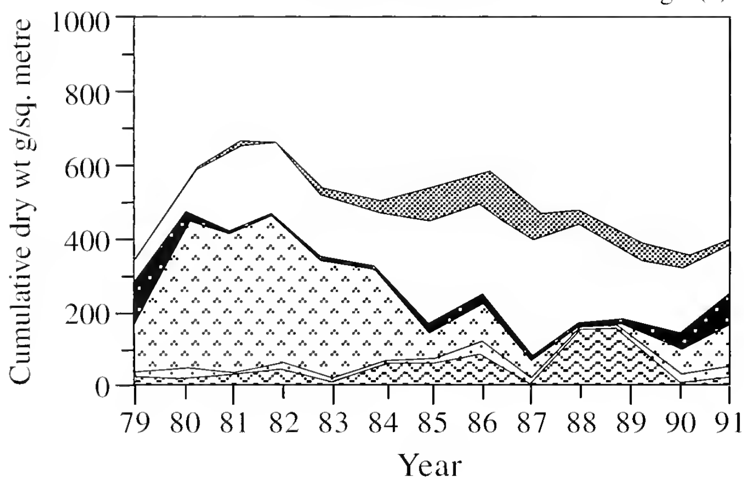
Treatment 2

Fig. 1(a)



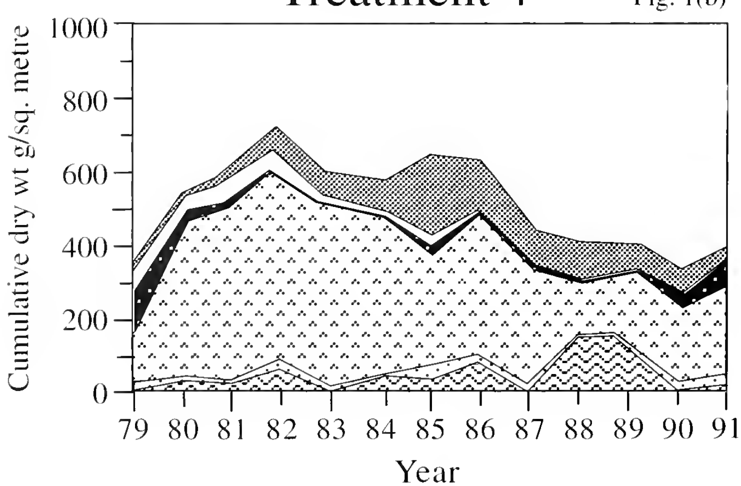
Treatment 3

Fig. 1(c)



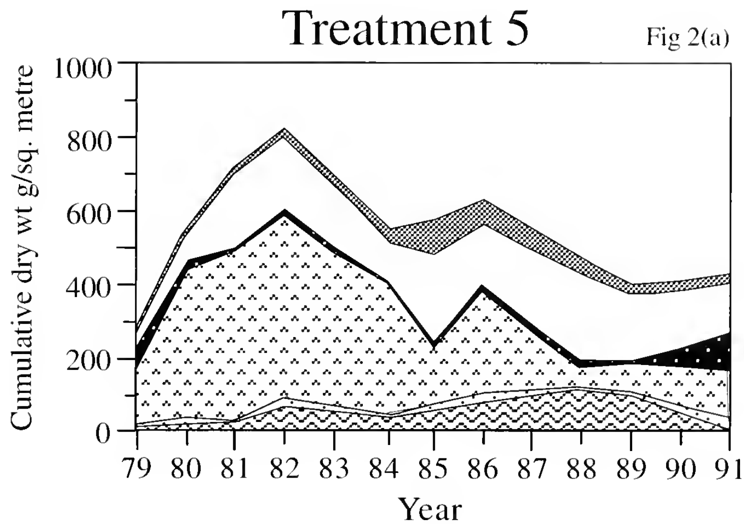
Treatment 4

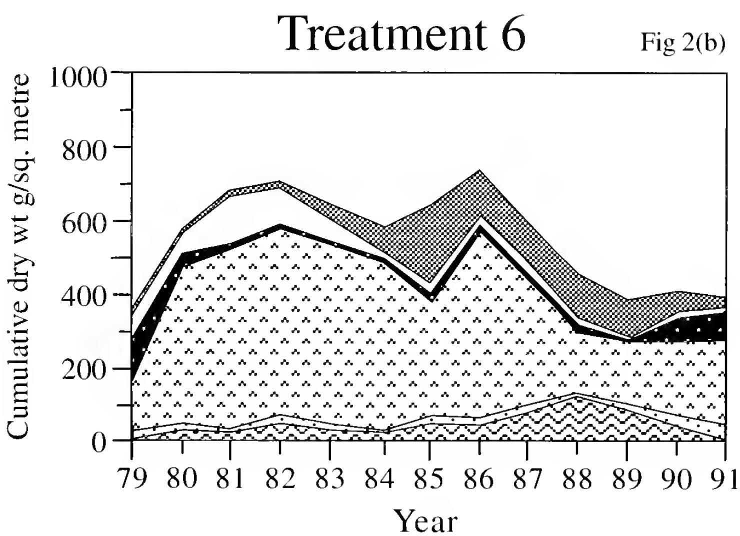
Fig. 1(b)

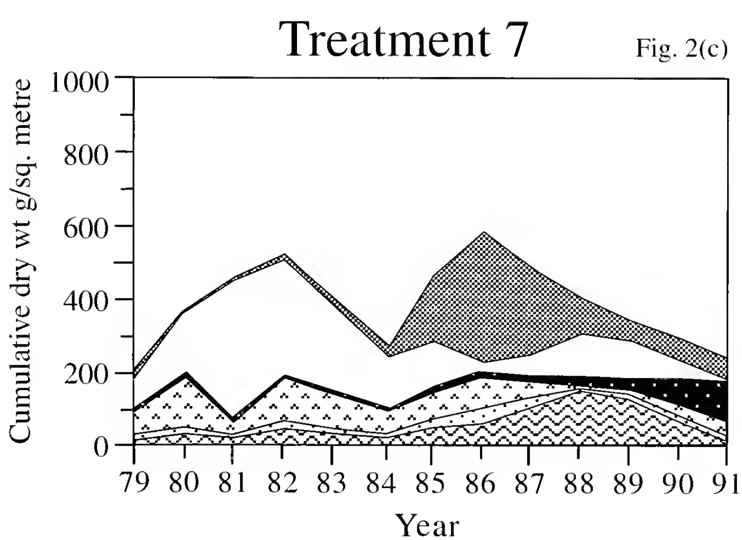


A Key to the shading used on each figure.

Figs. 1 & 2 Changes in the proportion of sown grasses, sown forbs, unsown grasses, unsown forbs, litter and mosses, and unidentified plant material (miscellaneous), 1979-91, in 6 wildflower mixtures sown in June 1978. See text and tables 1 and 2 for details.







Establishment of a wildflower grassland on a chalk soil

This experiment was sown in 1973 on an arable chalk soil at Royston, Hertfordshire which had previously grown 11 successive cereal crops. On the basis of detailed soil analysis, the site was classified as of intermediate fertility (extractable P, 1.43mg/100g, available N, 3.88mg/100g) in the scheme suggested by Allen *et al,* (1974). The experiment employed seven seed mixtures and a control (no seed sown) arranged in a randomised block design with 5 replicates. Plot size was 5 x 2m. Forbs were sown at a density of 100 seeds m^{-2}, grasses at 1000 seeds m^{-2}. Plots were sown on 17 April 1973. During the first 6 months after sowing, the plots were cut twice to control arable weeds, of which 26 were recorded, the most abundant being *Sinapis arvensis*. In subsequent years, plots were cut in early August and again in mid-October, mowings being removed at the first cut but left on the ground at the second. The main results from this experiment can be summarised as follows:

- Of the 40 forbs sown in 1973, 33 had established in 1981 (Table 3). The following 7 species failed to establish: *Blackstonia perfoliata, Centaurium erythraea, Cirsium acaule, Euphrasia nemorosa, Gentianella amarella, Pulsatilla vulgaris* and *Succisa pratensis*.

- Of the 8 graminoids sown, 6 established. *Carex flacca* and *Koeleria macrantha* failed. Grasses, especially *Bromus erectus*, now account for about 30-40% of the total cover and have spread into all plots.

- *Leucanthemum vulgare* was the most conspicuous forb in the first 2 years, accounting for 52% and 65% of total cover in 1974 and 1975 respectively, thereafter becoming less conspicuous. Once established, long-lived perennials, particularly *Centaurea nigra, Centaurea scabiosa* and *Sanguisorba minor,* increased in cover to form discrete patches around which shorter-lived species, such as *Medicago lupulina* and *Anthyllis vulneraria* are replaced annually.

- Fluctuations in the proportions of different species were most pronounced in the first 4 years after sowing but oscillation in the cover of forbs in the last 10 years has been much less, with the exception of *Rhinanthus minor* which, not surprisingly as an annual species without a persistent seed bank, fluctuates greatly from year to year.

- The time taken from sowing to first flowering varied considerably between species. Nineteen species flowered in the first year, 1 after 2 years, 6 after 3 years, 5 after 4 years, 1 after 6 years and 1 after 8 years.

- Control plots were colonized in the first year by species present in the soil seed bank (mainly arable weeds), but these were gradually replaced by chalk grassland species originating from seed sources in nearby plots. After 13 years the control plots had accumulated 28 forbs and 5 grasses of which *Bromus erectus* was the most abundant grass and *Centaurea nigra* and *Sanguisorba minor* were the most frequent forbs.

Conclusions

Grassland communities which colonise set-aside land consist mostly of a limited range of undesirable 'weed' grasses which are highly competitive. *Agropyron repens, Agrostis stolonifera, Arrhenatherum elatius* and *Holcus lanatus* are conspicuous and often prevent the ingress of low growing forbs. Under conditions of rotational set-aside it is not worthwhile considering establishing more diverse grasslands, but if non-rotational long-term set-aside becomes an option, sowing more diverse grasslands should be considered. This will be of particular relevance if the proposed 20 year non-rotational set-aside becomes common within the European Union.

Results from the two trials discussed in this paper indicate that attractive, species-rich grasslands can be established on ex-arable land within a period of two to three years, although these grasslands require some form of annual management if they are to maintain their floristic diversity. The long-term trends in the sown mixtures reported here indicate that the proportions of species in the mixtures change rapidly during the first three years but that after that period the magnitude of these changes is less. Nevertheless, 'catastrophic' events, such as exceptionally wet winters and hot, dry summers will result in considerable changes in the composition of the vegetation which are not always easy to predict. These results support the view that meadow grasslands, whether 'natural' or sown, are dynamic and change in composition in response to fluctuations in environmental factors.

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Table 1: Dicotyledons (forbs) used in 8 wildflower mixtures sown at Monks Wood, 8 June, 1978.

	Short Herb Mixture		Tall Herb Mixture		MM	BSH		
	T2	T3	T4	T5	T6	T7	T8	T9
Achillea millefolium							*	*
Anthyllis vulneraria	*	*	*					
Bellis perennis						*		
Centaurea nigra			*	*	*			
Centaurea scabiosa				*	*	*		
Daucus carota			*	*	*			
Filipendula vulgaris				*	*	*		
Galium verum *	*	*				*		
Geranium pratense				*	*	*		
Hypochoeris radicata				*	*	*		
Leontodon hispidus	*	*	*					
Leucanthemum vulgare	*	*	*	*	*	*	*	
Lotus corniculatus	*	*	*	*	*	*	*	*
Medicago lupulina	*	*	*				*	*
Medicago sativa							*	
Melandrium album				*	*	*		
Melilotus alba							*	
Pastinaca sativa						*		
Plantago lanceolata				*	*	*	*	
Plantago media *	*							
Potentilla sp.							*	
Poterium sanguisorba				*	*	*	*	
Primula veris *	*	*				*		
Prunella vulgaris *	*	*						
Ranunculus acris			*	*	*			
Rhinanthus minor *	*	*						
Silaum silaus			*	*	*			
Trifolium dubium						*		
T. pratense						*	*	
T. repens						*		
Total number of species sown	10	10	10	13	13	13	13	7

Key: T2 to T9 = Treatments 2 to 9 MM = Mommersteegs Mixture BSH = British Seed Houses Mixture.

Table 2: Grass component of 8 wild flower mixtures sown at Monks Wood, 8 June 1978.

	T2	T3	T4	T5	T6	T7	T8	T9
Agrostis tenuis						*	*	
Alopecurus pratensis		*			*			
Briza media	*			*				
Cynosurus cristatus								*
F. rubra ssp. commutata 'Cascade'						*		*
F. rubra ssp. commutata 'Highlight'				*				
F. rubra ssp. rubra 'Rapid'	*			*				
Hordeum secalinum		*			*			
Lolium perenne						*		
Lolium multiflorum 'Westerwolds'	*	*	*	*	*	*	*	*
Phleum pratense 'Eskimo'							*	
Poa pratensis							*	
Trisetum flavescens		*			*			
Total number of grasses sown	2	5	2	2	5	2	4	5

Table 3: Thirty-three dicotyledons (forbs) which established in a wildflower mixture sown at Royston, Herts in 1973. Still present in 1986.

Achillea millefolium	*Anthyllis vulneraria*	*Campanula glomerata*	*Campanula rotundifolia*
Centaurea nigra	*Centaurea scabiosa*	*Clinopodium vulgare*	*Daucus carota*
Filipendula vulgaris	*Galium verum*	*Helianthemum nummularium*	*Hieracium pilosella*
Hippocrepis comosa	*Hypochoeris maculata*	*Leontodon hispidus*	*Leucanthemum vulgare*
Linum catharticum	*Lotus corniculatus*	*Medicago lupulina*	*Onobrychis viciifolia*
Pimpinella saxifraga	*Plantago lanceolata*	*Plantago media*	*Primula veris*
Prunella vulgaris	*Rhinanthus minor*	*Scabiosa columbaria*	*Taraxacum officinale*
Thymus praecox	*Tragopogon pratensis*	*Trifolium repens*	*Veronica chamaedrys*

Arable Weeds and Set-aside: a Cause for Conservation or a Cause for Concern?

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Introduction

Set-aside continues to provoke strong feelings. Responses to a survey of farmers in the summer of 1993 included, "It's heartbreaking" and "We shouldn't have to do it" (King 1993). The criticisms reflect outrage at leaving land unproductive for economic motives at a time of perceived world food shortages. However, the economic and political situation which led to the introduction of set-aside is real enough (e.g. Floyd 1992), and set-aside will remain for several years at least. The more positive reactions to set-aside from King's (1993) survey accept this situation and look for benefits; "Great scheme!", "Outlaw natural regeneration", "Natural regeneration seems to provide more scope for wildlife". Here the attractions were economic, agronomic and environmental respectively.

Despite the feelings of some farmers, agriculture is not solely the business of producing food. There is an increasing market, in terms of grants and support measures, for high quality countryside. The quality can be assessed in terms of amenity, conservation value or environmental benefit such as reductions in nitrate leaching. Experience of the experimental Countryside Premium Scheme shows that high quality countryside can be delivered by longer-term set-aside; some areas have been used to provide feeding areas for geese, while others have been converted to much-appreciated grasslands for public access and enjoyment (Ewins & Roberts 1992). Set-aside can be used for the benefit of both people and wildlife, and farmers' standing in the local community can improve as a result (A. Rutherford, pers. comm.).

However, under the present regulations, much set-aside land is now managed on a rotational basis following cereals. Natural regeneration is commonly allowed, giving rise to a flora consisting of a mixture of arable weeds and volunteers (e.g Clarke 1992). Unless cultivated or frequently mown, it is often regarded as being poor quality countryside because of its derelict appearance. However, untidy stands rich in broad-leaved plants can provide valuable habitats and feeding areas for a wide range of animals, and rare plant species can sometimes thrive on first year set-aside land (Wilson 1992; Firbank et al., 1993). If managed appropriately, rotational set-aside can bring about considerable benefits to wildlife, albeit with potential risks of increasing weed problems for the rest of the cropping rotation. The weedy floras of early set-aside can be regarded as both causes for concern and causes for conservation, and conflicts of interest can arise between good agronomic practice and effective management for wildlife. In this paper, we address the potential benefits of rotational set-aside for conservation, with particular reference to scarce plants. We will then briefly address the fears about increasing weed infestations, before suggesting how the conflicts of interest between conservation and control can be minimised.

The arable habitat - a cause for conservation

When Tansley (1939) surveyed British vegetation, he did not regard arable habitats worthy of consideration, and this unreasonable attitude has tended to persist. Arable systems are purposeful, and under largely human control (Pearson 1992), but so are many other habitats, such as meadow and woodland coppice. The arable habitat has existed in Britain for thousands of years, and is contemporary with such more 'natural' habitats as heath or chalk downland (Potts 1991).

Arable fields are regularly disturbed, which limits the range of species which can persist. These plants typically have short life cycles, simple architecture and a high allocation to reproduction (Pearson 1992). In a typical intensive arable farming system, species diversity is relatively low (Pearson 1992), but that does not imply that the habitat is an ecological desert. Around 700 plant species occur in arable habitats in western Europe, and up to 300 in Britain, around 17 % of all flowering plant species (Wilson 1990). There are 61 common bird species of British lowland farms, many of which use arable fields especially when co-occurring with other habitats such as woodland, hedgerow and grassland (Lack 1992). Potts (1991) estimates that around 1800 species of insects and spiders have been associated with arable habitats in Britain.

Arable land is very extensive in area, occupying 21% of the land cover of Great Britain (Barr et al. 1993). In common with other agricultural habitats, its communities have suffered greatly as a result of intensification. Potts (1991) suggests that around half of the insects and spider species may have become extinct from British arable fields, and over the last twenty years declines in abundance have been observed of the order of 50 % per decade of many others species. Birds are declining far more from farmland than from other habitats; of those species which have changed in range in Britain between 1968-72 and 1988-92, 85 non-farmland birds increased and 89 decreased in range, whereas for farmland birds, 24 out of 28 species had decreased (Gibbons et al. 1993). These declines have been related to factors such as the loss of winter stubbles, increased application of pesticides and an increase in continuous monocultures (Gibbons et al. 1993; O'Connor & Shrubb 1986) - all signs of intensification of arable farming.

The botanical communities of arable habitats have also changed dramatically. The flora of arable fields probably changed little from the Middle Ages until the present century (Salisbury 1961). It was typified by broad-leaved species. For example, in 1809, the most troublesome arable weeds were *Anthemis arvensis*, *Capsella bursa-pastoris*, *Chenopodium album*, *Cirsium arvense*, *C. vulgare*, *Elytrigia (Agropyron) repens*, *Persicaria maculosa*, *Polygonum aviculare*, *Ranunculus arvensis*, *Raphanus raphanistrum*, *Rumex cripsus*, *Sinapis arvensis*, *Sonchus* spp., *Stellaria media*, *Thlaspi arvense* and *Veronica hederifolia* (Pitt 1809, quoted by Salisbury 1961). In 1917 the most common weed seeds in cereals were almost all broad-leaved species; in order, *Fallopia convolvulus*, *Sinapis arvensis*, *Galium aparine*, *Raphanus raphanistrum* and

Persicaria maculosa.. The now extinct *Agrostemma githago* was the twelfth most abundant, ahead of *Bromus hordeaceus* and *Avena* spp., the only grasses in the top 24 (Anon 1918). By 1952, *Galium aparine* and *Fallopia convolvulus* were the most frequent weed seed impurities, but *Avena fatua* was relatively more common than before (Broad 1952).

In 1961, Salisbury's (1961) list of important arable weeds was still largely composed of broad-leaved species. By 1970, the more herbicide-sensitive of these had declined substantially, such as *Ranunculus arvensis*, while more resistant species (grass weeds and some broad-leaved species such as *Stellaria media*) had increased (Fryer & Chancellor 1970). This national pattern was mirrored by the herbicide-treated continuous cereal plots of the Broadbalk experiment at Rothamsted, which between 1955 and 1967 showed increases in *Poa annua* and *Equisetum arvense* and declines of *Cirsium arvense, Ranunculus arvensis* and *Vicia sativa* (Thurston 1968; Firbank 1993).

The ITE Land Cover permanent plots witnessed a 38 % decline in number of species in arable areas between 1978 and 1990, and demonstrate that the shift from diverse broadleaved weed communities to grass weed communities has continued (Barr et al. 1993). The survey of British cereal fields by Whitehead & Wright (1989) showed *Stellaria media* to be the most widespread weed, followed by *Poa annua, Veronica persica, Matricaria* spp., *Galium aparine, Lamium purpureum, Viola arvensis* and *Avena fatua* - all species relatively resistant to herbicides. Like the ITE plots however, this survey recorded presence, not abundance, within fields and so may not correlate well with the severity of weed problems as perceived by the agricultural industry. However, a similar picture is given by recent results of the Official Seed Testing Station for England and Wales; for 1989/90, the most common impurities of cereal seed by far were volunteers, with *Avena* spp, *Anisantha* (*Bromus*) *sterilis* and *Galium aparine* being the only non-crop species found in above 1% of barley samples, and these species plus *Elytrigia repens* and *Poa trivialis* were the only ones found above trace levels in wheat samples (R. Flood, pers. comm).

The general story is one of loss of diversity, and a shift towards floras more dominated by grass and herbicide-resistant broad-leaved species. Herbicides are clearly an important factor, but by no means the only one; improvements in seed cleaning, the development of highly competitive modern cereal varieties and the increase in the amounts of nitrogen applied to them, the shift to winter cereals and to minimum tillage have all influenced which species can thrive and which cannot. Uncommon arable annual species tend to have very poor powers of seed dispersal, and are extremely poor colonisers (Wilson 1990), and so some species have sometimes become very rare indeed as their existing habitats have been lost or degraded. Indeed, the arable weeds are regarded as "the most severely threatened group of plants in the (British) flora" (Perring & Farrell 1983). Twenty three arable species were included in the British Red Data Book (RDB) for vascular plants, showing six extinctions (Perring & Farrell 1983). According to the recent Scarce Plant Survey (Stewart et al. 1994), even more species would now qualify for RDB status (Table 1), to which *Centaurea cyanus* may now have to be added (PJW, unpublished data).

The communities of arable land are not, and never have been, uniform across the country. ITE has created a 'Biotope Occupancy Database' which relates species to habitat, allowing maps of species richness associated with habitats to be generated (Eversham 1993). The data currently available for the arable habitat include scarce plants, vertebrates, molluscs and a wide range of insect groups. It is clear that the number of animal species typically associated with arable and fallow habitats is greatest on the lighter soils of south east England, although all parts of Britain are home to at least some of these species (Fig. 1). When scarce arable plants are considered, the concentration in south east England is even more marked, with far fewer sites occupied since 1970 (Stewart et al. 1994; Fig. 2). These data suggest that the present concentrations of scarce weeds on the lighter soils of southern England reflect their original ranges to some extent, but also result from range contractions from the more intensively managed areas of arable farming.

Observed benefits of set-aside to uncommon arable plants

Perennial vegetation requires several years to develop naturally on set-aside arable land. In a survey of the vegetation in the first four years of set-aside, carried out for the Game Conservancy between 1989 and 1992, the majority of species recorded in the first year were annuals and other species derived from the existing vegetation of the field, numbers of which declined between the first and third years, being replaced by biennials and perennials (Table 2) (Wilson 1992). Similar patterns have been recorded by other researchers (e.g. Clarke 1992). Before a continuous vegetation cover has developed, short-lived, poorly competitive species have opportunities to grow and reproduce that may be considerably more favourable than those offered within a highly competitive crop treated with agrochemicals. These species can include several of those cornfield annuals which have experienced such a rapid decline in recent years. The rate at which perennial vegetation colonises abandoned arable land can however vary greatly from site to site depending partly on soil type, being faster on more clay-rich soils and slower on lighter sandy or chalky soils (Clarke 1992).

The first and sometimes the second and third years of permanent set-aside may therefore offer good opportunities to annual and biennial species which are either already present in the seed-bank or which can colonise from nearby habitats. Rotational set-aside is ecologically the same as the first year of permanent set-aside and any benefits observed for the latter will also apply to the former. Several uncommon arable annuals have been observed in set-aside fields surveyed between 1989 and 1992, including some of scarce and RDB status (Table 3). In none of these sites were these species known before setting-aside, although presumably they had been present in the seed banks and were often recorded elsewhere in the area.

These early stages of the successional process also present opportunities for a group of plants which are not strictly arable annuals, but which are rather species of irregularly cultivated land. The rarest of these species are mainly found on south-facing field edges in the south and east of England, as well as in other habitats where perennial vegetation does not

form a continuous cover. Important populations of three RDB species, *Ajuga chamaepitys* in Surrey, *Filago lutescens* in Suffolk and *Gastridium ventricosum* in Dorset, have been reported from set-aside fields. Little is known about the life-cycles of the first two species, but it is likely that they do not coincide with farming practices sufficiently well to permit them to survive within conventionally cultivated fields or within typical rotational set-aside. *G. ventricosum* can certainly survive in low density cereal canopies similar to early set-aside (Trist 1983, 1986). The potential for flexibility of timing cultivations within the set-aside management prescriptions suggests that non-rotational set-aside may be very valuable for the conservation of these rare and threatened species.

How serious are weed problems on set-aside land?

In some cases therefore, the flora of a first-year set-aside field may be very rich. In other fields, however, the flora may reflect the effects of many years of agrochemical inputs, and be dominated by a limited range of grass weeds and volunteer crops (e.g Clarke 1992). Common and pernicious arable weeds can increase in abundance on set-aside land, especially where natural regeneration is allowed (e.g. Clarke & Cooper 1992; Lechner et al. 1992). The particular species composition of a field reflects geographic distribution of the weeds, local soils and past cropping conditions (Clarke & Cooper 1992). The principal weed problems perceived by farmers in King's (1993) survey in 1993 were *Alopecurus myosuroides* (45 % of farmers), thistles (41%), *Bromus/Anisantha* spp. (36 %) and *Avena* spp. (28 %) (King 1993). Of these, *Avena fatua* and *Alopecurus myosuroides* are especially troublesome in southern and eastern England. *Anisantha sterilis* is also a species of the lowlands, and is associated with minimum tillage.

Observing a weed infestation in a set-aside field is not the same as implying that weed problems are necessarily increased in following crops or in neighbouring fields. There can be seed rain from set-aside onto neighbouring fields, but only within a short distance of the source (Jones & Naylor 1992). The numbers of seeds involved are probably small - Jones & Naylor (1992) report less than 1% of the total seed rain - but could constitute the loci of new infestations.

The greater problem is the potential for increased levels of weed seeds in the seed bank under the set-aside land (e.g. Lawson et al. 1992), leading to increased levels of weeds in subsequent crops (e.g. Lechner et al. 1992). In general, such weed problems can be contained during the set-aside phase itself and in subsequent crops. For example, Clarke & Cooper (1992) reported no increased weed problems following natural regeneration and a rigorous cutting regime to try to prevent weed seeding. However, such widely adopted cutting and cultivation regimes control both common and rare plants and can be damaging to other wildlife. For example, the Game Conservancy 1993 national survey of rotational set-aside revealed that 93 % of farmers had cut, ploughed or chemically-fallowed their land by mid-June - the peak hatching time for partridges (P. Thompson, unpublished data).

In many cases such measures are probably not necessary. The levels of pernicious weeds in the year before set-aside will give a reasonable index to the farmer of what problems to expect, and the more noxious species are typically most abundant on heavier soils with a history of intensive cereal growing. Such sites are unlikely to be valuable for scarce species, and control should take the highest priority. Where there is mixture of common and rare species, selective herbicides on the Conservation Headland list developed by the Game Conservancy can be used to control the pernicious grass weeds whilst leaving the more valuable broad-leaved species (Sotherton 1991 - contact the Conservancy for updated lists). The seed return of the problem weeds may not be as great as is feared, as an unknown proportion of seeds will perish because of herbivory (n.b. Povey et al. 1993) and other factors, and in any case weeds can often be managed after set-aside by other selective herbicides and by using break crops.

What can be done to maximise conservation benefits for the arable flora?

Naturally-regenerating rotational set-aside offers an important opportunity for conservation. We have concentrated on the potential benefits to scarce plants, but there are other benefits to the wildlife of the arable habitat, notably wintering and breeding birds, insects and small mammals (Firbank et al. 1993). If these benefits are to be achieved, there needs to be an improved awareness among farmers and their advisors of the conservation potential of set-aside. Farmers must be made aware of the opportunities for conservation on their farm, they should incur no substantial financial losses, and the conflicts between justifiable weed control and conservation must be resolved.

Improving awareness

The 1992 scheme required cutting or ploughing of rotational set-aside in late spring, largely in order to control weeds. However, there were many complaints, as farmers realised that they were destroying nestlings of birds being raised on what had appeared ideal habitat. 45 % of farmers in the Game Conservancy survey (P. Thompson, unpublished data) volunteered the comment that their management had been bad for wildlife and game. Many farmers want to enhance wildlife on their land, and the new rules (MAFF 1993) give them far greater flexibility than was the case previously. Farmers need sound advice however, and while handbooks such as the ITE guide (Firbank et al. 1993) can help, much depends upon the network of advisors available to the farmer (e.g. Ewins & Roberts 1992).

Improving on-farm knowledge of conservation potential

The advisors and farmers together need to know the conservation potential of their own farm. They should locate populations of scarce species, and should identify fields with a flora suitable for conservation management. The management should be targeted to the particular species present, as some arable species require soil disturbance to germinate, and its timing can be critical (Wilson 1993, 1994). Here again, informed support to farmers and their advisors is essential if the conservation potential is to be realised.

There is no substitute for surveying the farm. However, it is possible in principle to use environmental databases to suggest what could be present. Botanical data held by the Biological Records Centre can be used to identify areas rich in diversity (e.g. Figs 1 & 2) and the distributions of particular rare species (e.g. Stewart et al. 1994). If these species are associated with particular soils, land use histories or management regimes, then the list of rare species can be narrowed down still further to help generate a check-list of species which may well be present on a particular farm. Databases are being developed for plants which would help in these searches (e.g Fitter & Ford 1993), but they do not apply to all rare species. It would a valuable exercise to construct a weed database for all British species, including data such as germination times, response to herbicides, nitrogen, ploughing etc, and seed bank behaviour as well as distribution.

Improving cost-efficiency to farmers

Rotational set-aside offers an extremely cheap form of conservation, excluding potential costs of future weed control. The land can be simply left, and even the more active forms of management, such as cultivation or the use of game mixtures, entail relatively few direct costs to farmers. Sites with particularly rare species, or of high diversity, could be supported further through management arrangements with local or national conservation bodies.

Conflicts between conservation and control

Managing rotational set-aside for weeds involves allowing weeds of many species to increase. The costs and benefits depend upon which species are present. Land on lighter soils in southern and eastern England, which has been managed at low intensity, with a long history of arable farming and a recent history of a diverse, broad-leaved weed flora, offers great potential for conservation with few risks of serious weed problems in the future. In contrast, land on heavier soils with a long history of intensive production and a history of grass weed problems is likely to offer few benefits for conservation, and the farmer should regard weed control as a higher priority. However, these are very general statements, and even heavy soils have their share of rarer species worthy of conservation (Wilson 1990), and some of the best remaining sites for the arable flora are on very heavy soils.

Many scarce weeds now inhabit the outer edge of the field only, and this can be managed differently from the field centre (Wilson 1994). This is the principle behind the Game Conservancy's Conservation Headland recommendations. Here the outer 6 m of the field are subject to a restricted herbicide and pesticide regime to allow broad-leaved weeds and their associated insect flora to flourish (Sotherton 1991). The costs to the farmer are low, as yield in this outer area is less than that in the main body of the field. Farmers should consider managing the headlands for conservation throughout the cropping/set-aside rotation, and managing the centre of the fields more explicitly for intensive production and weed control.

Conflicts between intensive agriculture and conservation cannot be eliminated, but they can be reduced given knowledge of the flora and fauna across the farm. Farmers should consider emphasising conservation where there are known to be rare species, on lighter soils and at field margins, especially in south east England.

Discussion

Set-aside provides a wonderful opportunity for increasing the diversity of habitats and of wildlife in the countryside, as long as it is managed appropriately (Firbank et al. 1993). Arable species in particular are in a position to benefit enormously from rotational set-aside. Rotational set-aside can resemble traditional cereal fields as the most common species are often volunteers from the previous crop, there are few if any inputs of fertilisers and pesticides, and the canopies are often rather open and diverse. These are exactly the conditions which many animal and plant species need, and so their numbers can increase with little, if any, intervention by the farmer.

We do not argue that rotational set-aside is always the best option for wildlife or for the farmer. There are opportunities for restoring heathlands, grasslands and other habitats which should take priority in situations which might otherwise favour only common weed species, notably if the land is adjacent to existing habitat or has been under arable farming for only a short time. However, species-rich arable fauna and flora can be lost needlessly if managed prophylactically for weed control, as happened widely under the 1992 set-aside provisions, or sometimes even if the habitat is placed under longer term set-aside without regular disturbance, allowing a rich arable flora to be replaced by a more closed, species-poor perennial sward.

Set-aside is still widely regarded as a flawed policy. If farmers and public perceive that set-aside is delivering genuine benefits to wildlife, then the antipathy will decrease, and rotational set-aside will take its place as one of many measures for improving the environmental quality of our countryside.

Fig. 1 Map of relative species richness of arable and fallow habitats. Data refer to birds, mammals and some insect groups, using the Biotope Occupancy Database. See text for details.

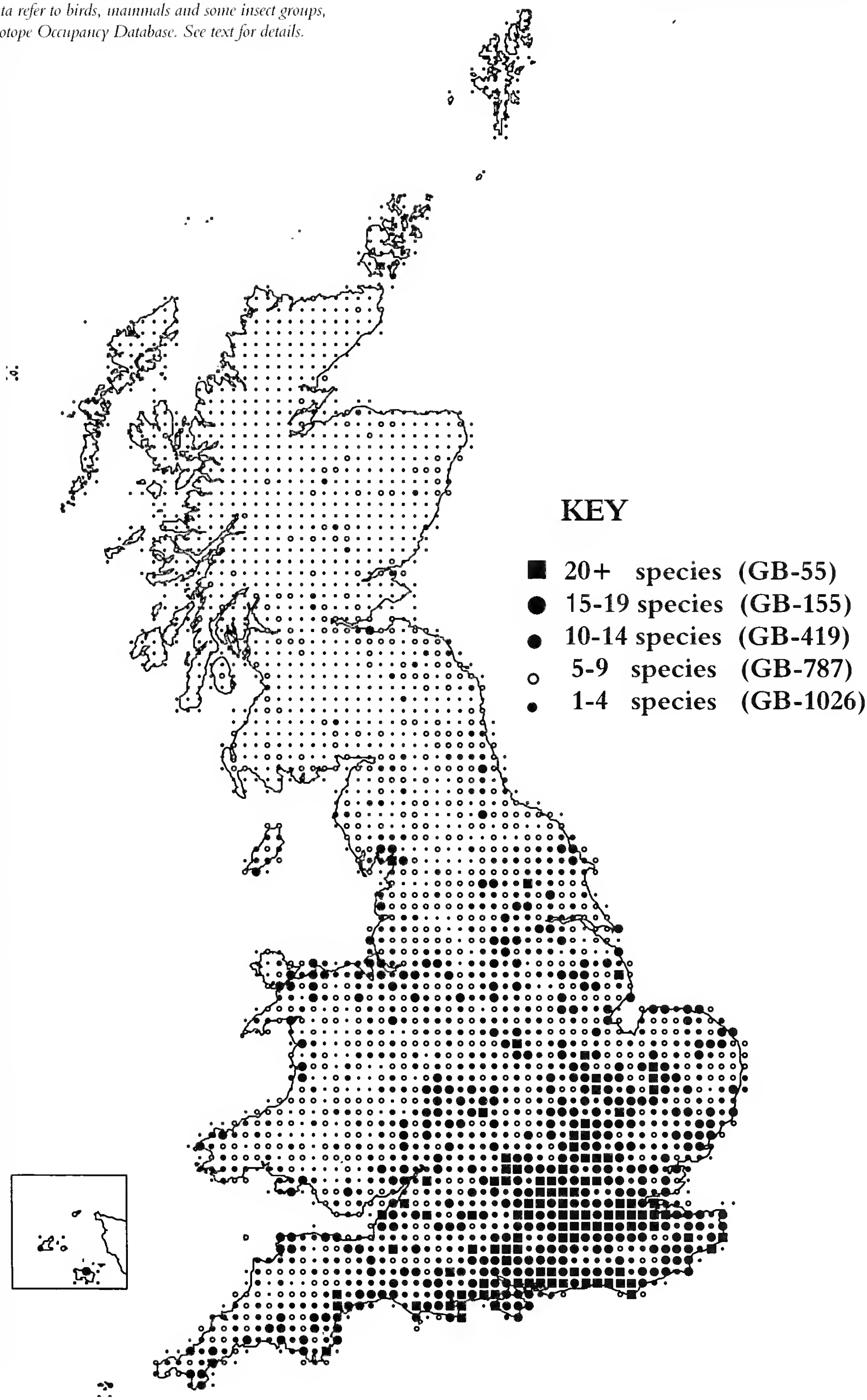
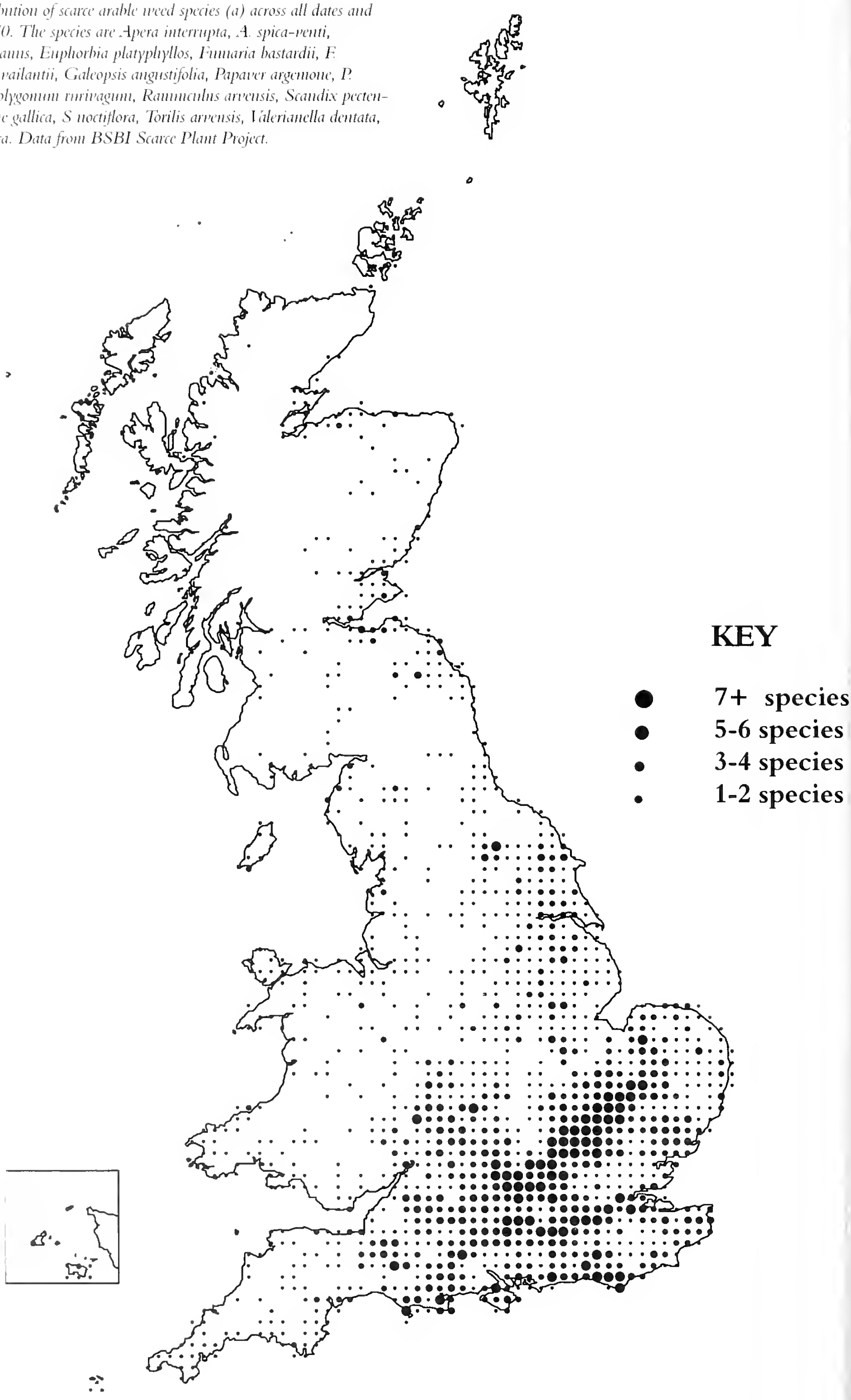


Fig. 2 Distribution of scarce arable weed species (a) across all dates and (b) since 1970. The species are Apera interrupta, A. spica-venti, Centaurea cyanus, Euphorbia platyphyllos, Fumaria bastardii, F. densiflora, F. vailantii, Galeopsis angustifolia, Papaver argemone, P. hybridum, Polygonum rurivagum, Ranunculus arvensis, Scandix pecten-veneris, Silene gallica, S noctiflora, Torilis arvensis, Valerianella dentata, Vica parviflora. Data from BSBI Scarce Plant Project.



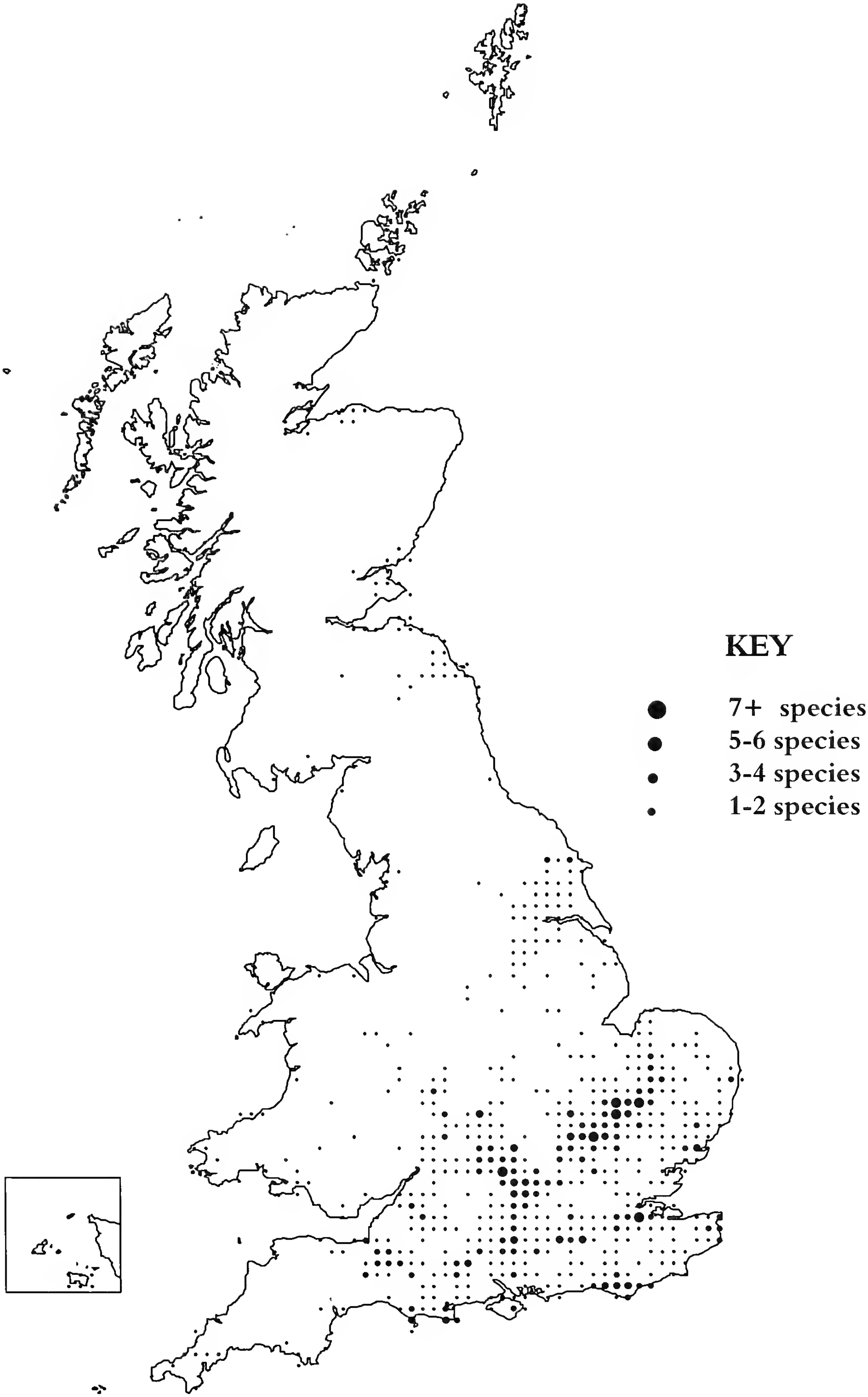

KEY
7+ species
5-6 species
3-4 species
1-2 species

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Table 1: Extinct, rare and scarce plants of arable habitats. Some species are also associated with other habitats (Perring & Farrell 1983, Stewart et al. 1994).

Extinct (can occur as casuals)

Agrostemma githago
Arnoseris minima
Bromus interruptus
Bupleurum rotundifolium
Caucalis platycarpos
Galeopsis segetum
Lolium temulentum

Red Data Book category (found in fewer than 16 10 km squares)

Adonis annua
Alyssum alyssoides
Anthoxanthum aristatum
Bunium bulbocastanum
Echium plantagineum
Filago lutescens
Filago pyramidata
Fumaria reuteri
Fumaria occidentalis
Galium spurium
Galium tricornutum
Gastridium ventricosum
Lythrum hyssopifolia
Melampyrum arvense
Rhinanthus serotinus
Teucrium botrys
Valerianella rimosa
Veronica praecox
Veronica triphyllos
Veronica verna

Scarce (found in between 16 and 100 10 km squares)

Apera spica-venti
Briza minor
Centaurea cyanus
Euphorbia platyphyllos
Fumaria parviflora
Fumaria vaillantii
Galeopsis angustifolium
Lathyrus aphaca
Scandix pecten-veneris
Silene gallica
Torilis arvensis
Vicia parviflora

Table 2

Percentage cover of bare ground and plant litter, total number of species, and number of species of three classes as proportions of the total number, expressed as mean values from 57 fields. Significant differences between years after harvest are indicated ($p<0.05$, *; $p<0.01$, **; $p<0.001$, ***). From Wilson (1992).

	Years since last crop was harvested. 1	2	3	
Bare ground (%)	30	5	5	***
Litter (%)	1	20	13	***
Total no. species	59	57	54	
Species with persistent seed banks (% of total)	46	34	28	***
Perennial species (% of total)	23	29	36	***
Other biennial & annual species (% of total)	25	31	30	*

Table 3. Uncommon cornfield annual plants recorded in set-aside fields surveyed between 1988 and 1991. (PJW, unpublished data)

Species	Year	Region	Geology
Adonis annua	2	South Wiltshire	Chalk.
Anagallis foemina	1	East Gloucestershire.	Oolite
Anthemis arvensis	1	Norfolk	Sand
Bromus arvensis	1-3	East Gloucestershire	Alluvial clay
Bromus secalinus	2	North Wiltshire	Alluvial clay
Misopates orontium	1-2	Hampshire	Sand
Papaver argemone	1	North Wiltshire	Chalk
Papaver hybridum	1	Hampshire	Chalk
Scleranthus annuus	1	Hampshire	Clay with flints
Silene noctiflora	1	Norfolk	Sand
Valerianella dentata	1-4	Buckinghamshire	Chalk

Genetic Consequences of Set-aside for Plant Populations and their Implications for Plant and Insect Conservation

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Introduction

Set-aside involves the temporary abandonment of normal cropping patterns on defined areas of agricultural land, and their replacement by a variety of possible alternative uses or management procedures. In order to analyse the possible short-term and long-term effects of set-aside on the biological communities of farmland and of the countryside in general, it is essential to consider a complete range of possible set-aside procedures, not limited to those that are permitted or favoured by current European Union regulations (MAFF. 1993a, b), and the term 'set-aside' is used in this wider sense in this paper.

The oldest and most elementary form of set-aside is simple abandonment of cultivation. In the past, this allowed the land to 'tumble to grass' if it was subsequently grazed, and it was formerly a common procedure in British agriculture. If neglect continued, the land might eventually revert to woodland, as in the landnam agriculture of a remoter past. Abandonment of cultivation of this type might be the consequence of a decline in crop yield, or of agricultural depression, or of war, pestilence or other disasters (Woodell 1985). Although it is thus no new thing, it may take a rather different course in the modern agricultural landscape, in which large areas of land may have become uniformly biotically impoverished but nutritionally enriched after long periods of intensive weed control and heavy cropping, perhaps with hedges and field banks removed. Few species may have survived to recolonise the land, and those that do may, for a period at least, produce unusual communities. On land that is less biotically impoverished, however, a familiar group of vigorous perennial weeds (in Britain, often common couch, *Agropyron repens* and/or black bent, *Agrostis gigantea*, rough meadow grass, *Poa trivialis* and creeping bent, *A. stolonifera* (Ingram 1977) with *Rumex* spp. and *Cirsium arvense*) tend to dominate the early succession on unmanaged set-aside land, after a flush of the surviving annual weeds. In the absence of grazing or mowing, these perennial weeds, perhaps joined by field-bank species like false oat-grass, *Arrhenatherum elatius*, and cock's-foot, *Dactylis glomerata*, can form a deep and persistent sward, often flowering and seeding profusely. Later, other species may spread from surviving fragments of natural or semi-natural vegetation, if any are present within effective dispersal range and if they are able to establish themselves in the new community; shrubs and trees with good dispersal mechanisms are most likely to succeed. These later stages of succession are unlikely to occur within the time-scale of temporary set-aside, in which the early, more variable, often species-poor and somewhat unpredictable community stages will predominate if active steps are not taken to ensure the 'green cover' required by current regulations or to promote other permitted objectives (MAFF 1993a,b).

A second, simple form of set-aside, again with a long history, is fallowing with cultivation. Cultivation is carried out in order to reduce the growth of perennial weeds and to prevent annual weeds from seeding; in semi-arid areas it also aids water conservation, but this is rarely of any significance in Britain. While it will undoubtedly reduce weeds in general and prevent the succession seen on uncultivated land, periodic cultivation of uncropped set-aside land imposes a new selective regime which may favour certain perennial weed species, and, within those species, genotypes which have particularly high tolerance to cultivation without cropping. The rapid spread of cape weed, *Oxalis pes-caprae*, in a sterile pentaploid form (Ornduff 1987) through cultivated but now uncropped Mediterranean olive-groves is an example of this process. Annuals with short reproductive cycles, especially variable and adaptable species like annual meadow grass, *Poa annua* (Law, Bradshaw & Putwain 1977, Warwick and Briggs 1978), groundsel, *Senecio vulgaris* and common chickweed, *Stellaria media* (Briggs, Hopkinson & Block 1991), may also be favoured. Current regulations for the management of rotational set-aside land (see Stewart Lane's paper) mean that it only partly fits this pattern. In this set-aside regime, early to mid-summer cultivation or mowing for weed control may carry the penalty of being destructive to potentially beneficial insects, birds and mammals that have been attracted to the weed stands on the fallow land to forage or breed, and current regulations specifically advise farmers to avoid cutting in the period from April to mid-July when birds are nesting and wild flowers are providing nectar and developing seed (MAFF 1993a).

A third form of set-aside, of a rather different type but also, in principle, with a long history (Thirsk 1985), is to change from the crop which is being produced in surplus to a different crop which is thought still to be in demand. In the present European context these substitute crops must also be permitted by agricultural regulations, and may be favoured by agricultural subsidies. The current complex regulations permit a wide range of non-food crops, including some conventional crops grown for non-food purposes (MAFF 1993a), but in Britain have tended to encourage the cultivation of unconventional crops such as linseed. The substitute crops themselves, if successful, tend to be produced in surplus and may then in turn be superseded by other crops, perhaps even less conventional or even entirely new to European agriculture, for example *Oenothera* spp. grown for evening primrose oil (Dodd & Scarisbrick 1989). New or unconventional crops always change, and often enhance, the resources and biological diversity of the countryside, both in themselves and because they are associated with microhabitats and weed floras which are likely to differ from those of the old crops. Techniques for weed control are likely to be different, less well understood and less effective than for conventional crops. New weed species may be introduced with the seeds of the new crop, or on specialised agricultural machinery associated with the crop. The new crop may fail, or be grown for a planting subsidy and not harvested, thus creating yet more new microhabitats and potential new selective pressures for existing biota. Finally, the crop itself may become naturalised as a weed, permanently altering and perhaps enriching the local flora (Salisbury 1961; Thirsk 1985).

A fourth potential form of set-aside is to change to an alternative temporary use of the land, which is active but largely or entirely non-agricultural. There is a wide range of possibilities, but current regulations severely constrain these by requiring

that these non-agricultural uses must not bring a return in cash or kind, unless they are activities which could be carried out if there were a standing crop on the land, for example game shooting. Permitted activities must also be compatible with the retention of the potential agricultural productivity of the land. Management for game conservation or nature conservation, with few differences from the first or second forms of set-aside apart from the deliberate creation of habitats suitable for game or wildlife, is favoured by many farmers, and is specifically permitted and indeed encouraged by current MAFF guidelines (MAFF 1993b; Game Conservancy Trust 1994).

Other possibilities, not permitted in the present Arable Areas Payments scheme, but potentially economically viable without subsidy, involve new recreational uses of the land, for example for golf courses, camping and caravan sites, motor sports, theme parks and other activities related to leisure and tourism. With the debatable exception of golf courses and similar semi-parkland uses, most of these potential recreational uses involve types of continuing disturbance and pollution which differ from those that existed in the traditional landscape. It may however be argued that they do not differ from, or are even preferable to, those that have been created by large modern pig-raising installations or intensive egg production units. Because they often require substantial investment in infrastructure (access roads, car-parks, serviced buildings, etc.), and are often seen as being potentially irreversible, such changes to new recreational uses tend to be discouraged by planning regulations. They are also subject to the same laws of supply and demand that should affect crop production. Nevertheless, the example provided by the reclamation for agricultural production of many wartime military camps, airfields and other installations suggests that, in the long term, land that had been used in a similar fashion for recreational purposes could be returned to agricultural use. Planning regulations should take account of the near-certainty that the return of the land to food production will become economically necessary in the future, and probably within a few decades at most, as world population and demand for food continue to increase. These regulations should ensure not only that land which has been temporarily adapted to recreational use can be returned to agriculture with minimal ecological disturbance and minimal waste of resources, but also that the conservation of the plant and animal communities of the countryside is assured during this cycle.

Plant habitats and plant populations in the British countryside

Our agricultural landscape consists of a mosaic of habitats. These are still diverse and closely juxtaposed on poorer soils, in topographically varied regions, and in less intensively farmed areas, especially in the west and in upland Britain, but are becoming increasingly simplified and uniform in the arable farmlands of southern and eastern England. Many of these habitats were created by human activities and typically require continuing maintenance if they are to retain their present form. They range from the entirely man-made habitat of arable land and rotational grassland, through a variety of grazed or managed grasslands, which may sometimes be ancient and species-rich, to heathlands, upland grasslands and moorlands that are likely to be maintained by a combination of grazing and burning. Hedgerows, orchards, plantations and managed woodlands, and a variety of waterside and aquatic habitats, also form essential components of the man-made agricultural landscape. They interact with other habitats and are often closely related to them (Woodell 1985).

Away from the coast, the predominant natural vegetation of the pre-agricultural lowlands probably survives in the most complete form in a few areas of ancient woodland, especially perhaps in pasture-woodlands like the New Forest where grazing has maintained diversity. However, throughout the countryside, many native species of woodland plant survive in fragments of old woodland and in hedgebanks (Godwin 1975; Rackham 1986). Their populations are increasingly subdivided, but are often likely to be lineally descended from ancestral populations that grew in the pre-agricultural forests. They are usually accompanied by a variety of naturalised or planted species.

The situation is less clear for plants of grassland and open habitats, although species-rich ancient grassland is one of the most diverse habitats of the British countryside, and one for which set-aside may provide conservation opportunities. Chalk grassland, and species-rich hay or grazing meadows like the Oxford meads, are probably descended from grasslands established after the Neolithic agricultural clearances. They were once widespread, but have been reduced to isolated areas and fragments, often so small and isolated that their viability is doubtful (Kay & John 1993). Their likely agricultural origin suggests that the recreation of new 'ancient' grassland on set-aside land, perhaps to form corridors linking surviving fragments of the original ancient grassland, might be both possible and acceptable, although it would be essential to ensure the use of appropriate genotypes of the plants that were involved.

Weed communities of arable land form another important element of the vegetation of the countryside. Like many ancient grasslands, they originated with the arrival of Neolithic agriculture. Some weed species were introduced with the seeds of the crops in which they grew (Kadereit 1990), but others may have spread into the crops from pre-existing native communities. Some cereal weed species, for example cleavers, *Galium aparine*, are quite widespread in natural communities, but the original native status or native habitat-range of such species is often uncertain. In other cases the forms of a species that grow in natural habitats may be genetically distinct from the weedy forms, and the latter may have been introduced, as for example in perennial sow-thistle, *Sonchus arvensis* (Pegtel 1973). To save the need for lengthy discussions in each case, the term 'native' is used in the present paper to describe long-established populations of weed species that are considered to be of medieval or earlier origin in Britain. Weed communities expanded and became richer as agriculture spread and became more complex, and as more weed species arrived or adapted to the new environment provided by arable land. They came to form an important element in the ecology of the countryside, providing habitats and food for many animals. The selective pressures that have affected the weed populations of arable land have always been strong, but were relatively stable through millenia of peasant farming. Since the introduction of better seed-cleaning techniques, tractor-powered tillage and effective chemical herbicides, farmland weed communities have been drastically altered and many weed species have been much reduced or even completely lost. Nevertheless, some of the more resistant

and adaptable weeds have survived or even increased, and new species (for example barren brome, *Anisantha sterilis* and pineapple weed, *Matricaria discoidea* and genotypes of herbicide-resistant forms of weeds (LeBaron & Gressel 1982) continue to invade agricultural habitats. The weed species that have maintained or increased their populations tend to be those with the ability to respond to changed selective pressures.

Weed communities and metapopulations are typieally fragmented both in space, because of the physical separation of cultivated fields, and in time, as a consequence of crop rotation or intermittent cultivation. The various set-aside procedures and possibilities will produce more changes in selective pressures, to which weed populations can be expected to respond. Set-aside provides excellent opportunities both for the conservation of threatened communities of scarce or declining weeds, and for the use of existing weed communities in habitat management for wildlife conservation. As with grassland species, the possible genetic consequences of management procedures should be taken into account, and appropriate native and local genotypes should be used if populations are re-established or augmented.

An important group of intermediate habitats, part weedy, part semi-natural, is formed by field-banks, hedgerows and roadsides (Pollard, Hooper & Moore 1974; Rackham 1986). Many field-banks and hedgerows have been destroyed in recent years, and the surviving stretches have often been strongly affected by herbicide and fertiliser drift and other factors that have much reduced their diversity and increased the proportion of weedy species. Re-establishment of field banks and hedgerows is often both agriculturally (Thomas, Wratten & Sotherton 1991) and environmentally desirable, but their plant communities are likely to differ from those of the past. Field-banks in the English lowlands, once renowned for cowslips (*Primula veris*) and summer flowers, now tend to be dominated by deep swards of a few vigorous grasses and perennial weeds, for example *Agropyron repens, Agrostis gigantea, A. stolonifera, Arrhenatherum elatius, Cirsium arvense, Convolvulus arvensis, Dactylis glomerata, Heracleum sphondylium* and *Urtica dioica*. Annual species are fewer but often include the conspicuous scrambler *Galium aparine* and, increasingly, the aggressive annual grass *Anisantha sterilis*. These field-banks are likely to provide one of the chief sources of colonisers for set-aside land, especially in the absence of active management.

Breeding systems, reproductive strategies and genetic variation in set-aside weed populations

The breeding system and reproductive strategy of a plant species are fundamentally important in determining its patterns of genetic variation and the genetic response of its populations to changing conditions. Breeding systems and reproductive strategies vary widely among plant species, far more than in most groups of animals. Plants, especially perennial herbs and grasses, commonly show much intraspecific genetic variation, often with close local adaptation to habitat conditions and rapid response to selection, as for example in sweet vernal-grass, *Anthoxanthum odoratum* (Snaydon 1970, Davies & Snaydon 1976). Despite their importance, breeding systems and patterns of variation are often poorly understood in plants, with only a minority of species having been investigated even in the comparatively well-studied European flora (Richards 1986). Their implications and importance for ecology and conservation are often not fully appreciated.

Because of the instability and unpredictability of their habitat, the breeding systems and reproductive strategies of farmland weeds are of particular interest. Amongst annual weeds, many species are self-compatible and normally self-fertilized, and consequently consist mainly or even entirely of homozygous biotypes, perhaps with only one biotype in a local population, especially if it is recently-established. Low but significant levels of outcrossing have nevertheless been demonstrated in several predominantly selfed annual weed species, for example annual meadow-grass, *Poa annua* (Ellis 1974) , *Senecio vulgaris* and *Stellaria media*. Self-fertility greatly facilitates colonisation, as for example in *Matricaria discoidea* and in the facultatively annual American willowherb, *Epliobium ciliatum* (Salisbury 1961; Preston 1989). Although selfing annual weeds are often very plastic phenotypically, their genetic response to selection is limited by the absence or rarity of heterozygosity and recombination. If more than one biotype is present, a change in selective pressure may result in a change in the proportions of the biotypes. This may be an inadequate response if the change in selective pressure is unidirectional, for example a change resulting from the adoption of a new agricultural practice. The absence of further genetic response in these species may however be advantageous if the change is temporary, for example the changes from season to season that affect successive generations of ephemerals, or the changes from one year to another in weather conditions, which vary unpredictably around a norm. In addition, self-fertility can enable new, better-adapted genotypes to spread more rapidly than would be possible in outbreeders, either simply because self-fertilization is possible e.g. *Senecio vulgaris* with maternally inherited herbicide resistance (LeBaron & Gressel 1982), or because well-adapted homozygotes will not be affected by outcrossing.

Although many self-compatible annual weeds are almost entirely inbreeding, some are partial outbreeders, self-compatible but with varying though probably significant degrees of outcrossing. Wind-pollinated annual weeds with this type of breeding system are often abundant and comparatively successful; examples include black grass, *Alopecurus myosuroides , wild oat, Avena fatua* and several other robust grass weeds, for example the bromes, as well as some wind-pollinated broad-leaves like fat-hen, *Chenopodium album*. In contrast, most of the insect-pollinated annual weeds with this type of breeding system are in decline in Britain, sometimes to near- or complete extinction; examples include pheasant's-eye, *Adonis annua* , corncockle, *Agrostemma githago* and cornflower, *Centaurea cyanus*.

Fully outbreeding annual weeds are typically large-flowered, tall and robust (often able to compete on equal terms with the crop) and strongly self-incompatible, Examples of insect-pollinated species of this type in Britain include corn marigold, *Chrysanthemum segetum* (Howarth & Williams 1972), common poppy, *Papaver rhoeas* (Lawrence, Afzal & Kenrick 1978), wild radish, *Raphanus raphanistrum* (Sampson 1967; Kay 1976), charlock, *Sinapis arvensis* (Ford & Kay 1985;

Stevens & Kay 1989) and scentless mayweed, *Tripleurospermum inodorum* (Kay 1969); wind-pollinated examples are fewer but include the grass *Apera spica-venti* (Warwick, Thompson & Black 1987). Many of them contrast with typical inbreeders not only in their breeding systems and (in cases where this has been investigated) in having much higher levels of genetic variation and especially heterozygosity, but also in their ecologically apparently more dominant roles and greater apparent ability to cope with environmental change. This may partly result from their more conspicuous appearance; flowering poppies, mayweeds and charlock are very easy to see in crops or on roadsides, but small-flowered inbreeders may escape attention. Nevertheless, mayweeds and charlock, for example, do appear to have thrived and increased in new types of disturbed environment such as those provided by motorway construction sites. During the First World War mayweeds and field poppies became extremely abundant in the disturbed ground around the trenches of the front lines in northern France (Hill 1917).

Like the crops with which they grow, outbreeding annual weeds usually have full annual life-cycles, germinating in autumn or spring and requiring several months of growth after germination, so can be fairly easily controlled by cultivation, especially in cultivated fallows. In some cases they have been less easy to control by herbicides, probably as a consequence of selection for increased herbicide resistance (LeBaron & Gressel 1982). On land where their seeds are present in the soil they may be conspicuous features of the early set-aside succession after cultivation, but like most other annuals will disappear in the later stages of succession, as perennials take over to form a closed sward. If the annuals have been able to form seeds they will augment the soil seed bank of dormant seeds of their species.

Reproductive strategies vary widely in perennial weeds. Although perennial weeds commonly reproduce and spread mainly or even entirely by vegetative means, seed production plays an important role in many species, both genetically (because seed production is always linked to sexual reproduction, except in agamospermous species) and for types of dispersal and establishment that cannot be achieved by vegetative means. Unmanaged set-aside conditions would be likely to favour flowering and seed production in many perennial weeds. This is especially significant for perennials in which flowering has been largely or completely suppressed by normal agricultural regimes. Local populations of these species may previously have consisted mainly of a few clones, perhaps limited to sites that they could reach by vegetative spread, and possibly weakened by systemic viral or fungal infections. In these populations set-aside could provide an opportunity for a period of genetic recombination, selection and adaptation, and for elimination of systemic infections by seed reproduction, in addition to dispersal to new localities by seed. The mowing requirement of current set-aside regulations (MAFF 1993a) will suppress or limit these effects, but will not prevent the rapid clonal spread of well-adapted genotypes that is likely to take place in stoloniferous and rhizomatous species. Possible examples of species that are likely to show all these effects include *Agropyron repens, Agrostis gigantea, Cirsium arvense, Convolvulus arvensis* and *Sonchus arvensis*.

Perennials with other reproductive strategies may be affected by set-aside in different or additional ways. *Arrhenatherum elatius* (Mahmoud, Grime & Furness 1975), *Dactylis glomerata* and *Urtica dioica*, for example, grow mainly on field banks and in hedgerows under normal arable regimes, flowering and seeding fairly freely. Set-aside may enable them to spread much more widely onto former arable land, but will not be associated with previously unavailable opportunities for recombination and selection. The docks *Rumex crispus* and *R. obtusifolius* which can persist vegetatively in some arable regimes, but spread only by seed, would be able to flower and seed freely in unmanaged set-aside regimes, as they do in neglected sown pastures, but the mowing requirement of set-aside will largely prevent this. The small number (in Britain) of weedy perennials that reproduce chiefly or only by bulbils or tubers, for example wild onion, *Allium vineale* and some increasing *Oxalis* species, will not be favoured by unmanaged set-aside but are potentially particularly well adapted to cultivated-fallow regimes, although selective effects are likely to be limited to interclonal differences. A few rhizomatous or stoloniferous perennial weeds reproduce (in Britain) only by vegetative spread, but can be very persistent and successful where they occur, and are likely to spread in set-aside land if they already grow on it or nearby, or are introduced to the site. The most conspicuous example is Japanese knotweed, *Fallopia japonica,* which can exclude most other vegetation; other less dominant examples include winter heliotrope, *Petasites fragrans*, and (in mown grassland) slender speedwell, *Veronica filiformis* (Harris & Lovell 1980). Most or all British populations of these species probably consist of genetically uniform single clones in which no direct intraspecific selective effects can occur, although the presence of these introduced species will affect the selective pressures on other species.

Agamospermous (seed apomict) complexes in dandelions, *Taraxacum* spp. and in brambles, *Rubus fruticosus* sensu lato, are successful and diverse in agricultural habitats. A range of microspecies of *Taraxacum* occur in grasslands of various types as persistent perennial herbs, especially on roadsides and in older sown pastures and hay-meadows. Their wind-dispersed seeds enable them to colonise newly available sites rapidly, and they are likely to become abundant on suitable set-aside land. Brambles have a different life-form and ecology, with a wide range of microspecies growing as scrambling, bushy subshrubs in hedgerows and scrub, and are common and abundant colonists of neglected agricultural land, spreading both vegetatively and by the bird- and mammal-dispersed seeds of their berries (Weber 1987). The importance of both groups of plants for set-aside communities lies in their ability to colonise rapidly and in their provision of a range of resources and microhabitats, varying from microspecies to microspecies and thus increasing the diversity of the environment. Because of their mode of reproduction, strictly agamospermous microspecies of dandelion or bramble are essentially clones which reproduce both vegetatively (only to a limited extent in dandelions, except when aided by ploughing or rotavating, but vigorously in many brambles) and by seed, but without genetic change. Selection thus acts between clones, affecting their relative success and frequency, but normal sexual recombination, gene-flow and genetic adaptation in response to environmental change do not occur. New genotypes can arise by occasional mutation or partial breakdown of normal agamospermy, and there is some possibility that set-aside might provide additional opportunities for the establishment of such new genotypes, but this is unlikely to be of great significance.

Set-aside management regimes and the conservation of natural habitats

In regions where significant areas of land are involved in set-aside, it will play an important part in shaping the ecology of the agricultural countryside. Set-aside is intended as a temporary expedient, but like other recent changes in agricultural practice it is likely to have wider-ranging effeets on the countryside, some of which may be permanent. These effects will depend on the type of set-aside that is involved and on the management regimes that are used. Their most immediate influence will be on the ecology of cultivated land, including the weed communities of cultivated land and the surrounding plant and animal communities that depend on agriculture, or interact with it. In addition, set-aside is likely to affect the enclaves and remnants of natural and semi-natural communities in the countryside. Several set-aside options include management regimes which are intended to re-create, augment or protect these remaining fragments of natural, non-agricultural habitats, or to protect biodiversity within agricultural habitats. Although these may often be successful in the short term, set-aside in its present form is unlikely to continue for many years and has uncertain and limited value for the long-term conservation of countryside habitats. It is particularly important to ensure that set-aside programmes do not threaten the long-term survival of natural and semi-natural habitats or compromise their integrity.

The basic options in the current scheme for five-year non-rotational set-aside in the United Kingdom, have already been summarised by Lane (see page 4).

Within the context of these permitted basic options, the management of set-aside land for environmental conservation is strongly advocated in current MAFF advice to Farmers (MAFF 1993a). Seven possible environmental objectives for set-aside land, with detailed advice for conservation management and the addresses of organisations from which further advice can be obtained, are listed in the advisory pamphlet AR14, published in August 1993 (MAFF 1993b). These are as follows:

- **Minimal cultivation for rare arable weeds and other plants**. This is envisaged for land with a long history of arable use, typically but not always on light sandy or chalky soil of low fertility, without significant levels of noxious weeds. The advice implies, but does not specify, that the species to be encouraged should regenerate from dormant seeds or propagules that survive on the land itself. Field edges may be particularly suitable for this option, because of their greater species richness (Marshall 1989). Farmers are recommended to seek further advice from a list of environmental organisations including the Game Conservancy Trust, English Nature, the Countryside Council for Wales and the Royal Society for Nature Conservation.

- **Sites for ground nesting birds**. Examples are lapwing, skylark and stone curlew, especially the latter; further advice from the Royal Society for the Protection of Birds is recommended.

- **Pasture for wildfowl, including geese**. This is envisaged as a variant of the grassland option (see page 5), although an exemption from the normal rules would be needed for the recommended grass cover, because this includes white clover and also requires nitrogen fertiliser treatment. The aim is to provide feeding areas for overwintering wildfowl such as brent geese (*Branta bernicla*) or wigeon (*Anas penelope*), and the sites will need be sufficiently large, open, and preferably in viable groups or near to existing wintering areas. The grassland would be fertilised annually in late September or October to create a palatable sward, and mown several times during the summer to ensure that the sward is no more than 5 cm high in the autumn.

- **Wild bird cover**. Though the objective is to provide cover and forage for wild birds, agricultural weeds, and many insects of agricultural habitats will also be favoured. This option provides a means of encouraging game birds, which under current regulations may provide a permissible return in cash or kind (because they might also have been favoured by a normal crop).

- **Otter havens**. This possibility is envisaged for riverside land in non-rotational set-aside, as a variant of the natural regeneration option (see page 3); an exemption will be needed because the vegetation will remain uncut for a considerable distance (about 50 metres) from the river bank, which should have some mature trees, but (to avoid disturbance by people and dogs) no footpath. Some native trees or shrubs (ash, oak, holly, hazel and blackthorn are listed as examples) may be planted or encouraged to regenerate. An additional advantage is that the sites will provide havens for waterside birds, plants and inseets.

- **Restoration of sandy grassland**. This variant of combined grassland and natural regeneration options needs no exemption, and aims to establish a low fertility site on which a flora typical of sandy grassland can develop. It is advised to be suitable only for sandy soils with naturally low fertility and pH; a sward should be established either by natural regeneration from adjacent sandy grassland, or by seeding with appropriate grasses, preferably species which are found in the locality. Light grazing between 1 September and 14 January is advised; this is permitted under set-aside rules. If successful, this set-aside possibility has clear and potentially substantial benefits for both plant and insect conservation.

- **Restoration of damp lowland grassland**. This is another variant of the natural regeneration option, recommended only for sites of moderate to low fertility with poor drainage; the soil should be a surface water or ground water gley or peat. The advice points out the importance of wet grassland for breeding and winter feeding

of many birds, including waders, geese, swans and ducks, in addition to its importance for invertebrates and damp grassland plants. It is recommended that, for natural regeneration of native wetland species to stand a good chance of success, the land should be a former hay meadow or pasture which had been converted to arable less 25 years ago. If it is not or if natural regeneration is unsuccessful, it may be necessary to seed the area with suitable species or with hay harvested from local wet grassland. Frequent mowing may be needed at first to reduce soil fertility and control undesirable weeds and aggressive grasses, perhaps with a subsequent hay cut after 1 September, and light early-autumn grazing after the same date (both are permitted under set-aside rules, provided that the grass was cut without removal during the summer). Again, this set-aside possibility, if successful, clearly has substantial potential benefits for conservation.

Restoration of calcareous grassland was not included in the possibilities covered by AR14, perhaps because it was considered that calcareous grassland is less threatened than sandy grassland and damp lowland grassland. While this may be correct, it is unfortunate that some guidelines were not included, because there are much greater areas of set-aside land on suitable calcareous soil, often adjacent to calcareous grassland remnants, and there is active interest In the creation of artificially sown calcareous grasslands, and in their insect fauna (e.g. Wells, Bell & Frost 1981; Wells 1984, Morris 1990). If inappropriate grasslands are established on these set-aside areas, perhaps including invasive alien species and non-native genotypes of indigenous species, it is likely to have an adverse effect on the remaining native calcareous grassland. Similar considerations apply to the other grassland options but have been taken into account in the published guidelines, although there is a danger that they will be overlooked in practice.

Set-aside management regimes and genetic conservation

1. In weeds of arable land and field-margin plants

Snaydon (1980), in a survey of plant demography in agricultural systems, remarked that surprisingly few studies had been made of the genetic structure of populations of annual weeds. Despite the availability of rapid and effective electrophoretic techniques for such studies, this is still true. Only a small minority of weed species have been investigated electrophoretically, most of them widespread and abundant in the areas where they have been studied, for example the grass, *Apera spica-venti* (Warwick, Thompson & Black 1987), wild oat, *Avena fatua* (Imam & Allard 1965; Jain & Rai 1974) and shepherd's-purse, *Capsella bursa-pastoris* (Bosbach & Hurka 1981). More information about genetic variation in weed populations has come from studies which have centred on a few easily characterised genetic factors such as incompatibility alleles (Lawrence, Afzal & Kenrick 1978, *Papaver rhoeas*; Ford & Kay 1985, Stevens & Kay 1989, *Sinapis arvensis*) or herbicide resistance (LeBaron & Gressel 1982), or have used morphological characters that are maintained in comparative cultivation (Akeroyd & Briggs 1983, *Rumex crispus*; Briggs, Hopkinson & Block 1991, *Stellaria media*; Fabri 1989, *Aethusa cynapium*). In addition to demonstrating high levels of genetic variation in fully or partially outbreeding weeds, these studies have shown that populations of inbreeding weeds commonly consist of a range of biotypes amongst which there is limited but significant gene-flow, and that rapid selective response can occur in genetically variable populations of annual weeds. In nearly all cases significant regional and geographic differentiation is likely to have taken place, both as a consequence of selection and by stochastic processes, especially during the colonisation of a new geographic area. Similar findings have been made for perennial weed species, particularly those that also occur in natural habitats, for example *Agrostis stolonifera* (Kik et al. 1990) and *Plantago lanceolata* (Tienderen & Toorn 1991). These findings have important implications for set-aside management regimes. In the first place, it is clear that weed populations are likely to show genetic change in response to the changed selective pressures imposed by novel management regimes. Secondly, the existence of genetic differentiation between local populations must be taken into account in programmes which are intended to conserve scarce and declining weed species. The same considerations apply, with equal or even greater weight, to set-aside related conservation programmes for scarce and declining field-edge and grassland species.

The possible genetic effects of new set-aside regimes on pre-existing populations of common weed species have already been discussed. In addition to these effects, the possible results of deliberate introductions need to be considered. Recommended set-aside conservation management regimes generally do not involve sowing common annual weed species, but a number of these species are included in commercially available 'wild flower seed' mixtures which may be sown as part of local conservation schemes. The seeds in these mixtures are often derived from Continental European or Mediterranean sources, or even from garden cultivars (for example the pansy, *Viola tricolor*). They are likely to be genotypically different from native populations of the same species. For example, plants of stinking chamomile, *Anthemis cotula*, *Chrysanthemum segetum* and *Papaver rhoeas* grown from a commonly available 'wild flower seed' mixture have smaller, less attractive flowers (and perhaps greater self-compatibility, Kay 1971) than native British populations. Occasional introductions of these alien genotypes may of course have taken place in the past, for example as crop-seed contaminants or with ballast, but are unlikely to have changed the genotypic composition of long-established native populations unless new and selectively superior alleles were involved. Deliberate introductions to biotically depleted farmland may have a different outcome. In some cases, there is a possibility that aggressive new genotypes of weed species may become established. For example, the tetraploid cytotype of *Tripleurospermum inodorum*, which is the normal form of this common, large-flowered and rather attractive species in central and eastern Europe, has been known in the past only as a rare and apparently impersistent introduction in Britain, probably because the abundant native diploid populations of *T. inodorum* exclude it by minority cytotype disadvantage (obligate allopatry, Kay 1969). If tetraploids were to be deliberately established in Britain via 'wild flower' weed mixtures sown on set-aside land where diploids did not occur, they might prove to be an unwelcome and aggressive addition to our flora. The consequences of such introductions of new plant genotypes for the insect fauna are uncertain but seem likely to be minor unless the range, abundance or phenology of the plant species is affected. For example, differences between North and South German populations of *T. inodorum* in the

associated insect complex were found to be minor and largely quantitative by Freese & Gunther (1991) although these populations are likely to include both cytotypes (Kay 1969).

The effects of set-aside-related conservation programmes on the genetic composition of populations of rare or scarce and declining species of weed, field-margin and restored-grassland species are potentially much greater, and need careful consideration and appropriate precautions. Genetic screening of existing populations should be an essential part of any conservation programme for rare or declining species. The patterns of genetic differentiation that are likely to be found in scarce and rare plants are diverse, and depend on several factors. These include the breeding system of the species, the history, size and structure of local populations, their reproductive biology, the degree of isolation between individuals and populations, the intensity of natural selection and the extent of hybridisation with other taxa (Barrett & Kohn 1991, Kay 1993).

These patterns of variation may both depend on, and provide information about, the history and inter-relationships of individual populations. Good examples of contrasting patterns of variation in British populations of the rare annuals small rest-harrow *Ononis reclinata* and early sand grass *Mibora minima* have been described by John (John & Kay 1989, John 1992). The breeding system, reproductive biology and pattern of genetic differentiation of a rare plant taxon must be understood not only for conservation and, especially, recovery programmes to have a real chance of success, but also to avoid endangering existing populations and to avoid losing, contaminating or distorting the existing pattern of variation. This is often in itself an evolutionary and historical document of great interest and value, not only in absolutely rare species, but also in locally rare species. The same considerations apply to rare insect species with isolated breeding populations. Patterns of genetic variation can now be monitored rapidly and inexpensively in many plant and animal species by isozyme electrophoresis (e.g. Lack & Kay 1987; Lonn & Prentice 1990; Schaal, Leverich & Rogstad 1991), and genetic screening of existing populations should be an essential preliminary step in any active conservation programme for rare species. Without this knowledge much harm may be done. Despite this, many programmes for rare species have either effectively ignored genetic effects, or extrapolated inappropriate theoretical models to real populations with quite different characteristics, for example by indiscriminate use of the concept of minimal viable population size (discussed by Lesica & Allendorf 1992).

Because of the rapid decline in many plant and insect species which were associated with habitats that were maintained by traditional agriculture, set-aside provides many potential opportunities for conservation or re-establishment of populations by the maintenance or re-creation of suitable habitats. A large number of species are potentially involved; Tables 1 and 2 list a selection of the rare and scarce species that were included in the *British Red Data Book* (Perring & Farrell 1983; Whitten 1990) or in *Scarce Plants in Britain* (Stewart, Pearman & Preston 1994) and grow in such habitats. The hazards associated with reintroductions have already been discussed; the sowing of rare weed species in cereal fields was not considered to be an acceptable technique for their conservation by Wilson (1991) and for rare species in general such programmes should be undertaken, if at all, only with careful genetic monitoring and appropriate precautions (e.g. Pigott 1988, *Cirsium tuberosum*). Weed species that were formerly maintained by repeated introduction as seed contaminants, with little or no persistent seed bank, and are now very rare or extinct in Britain, are a possible exception; likely examples are *Agrostemma githago* (Firbank 1988; Thompson 1973) *Bromus interruptus* (Donald 1980) and *Centaurea cyanus* (Schneller 1980). Even for these, genetic screening of the founding populations is an essential preliminary step, especially for *A. githago* (Hammer, Hanelt & Knupfer 1982) and *C. cyanus* which are often included in 'wild flower seed' mixtures as inappropriate garden cultivars. Programmes depending on surviving seed banks that are still present in the soil, for example involving *Fumaria* species (James 1989), henbane, *Hyoscyamus niger* (Garrad 1989) or spreading hedge parsley *Torilis arvensis* (Southam 1989) are much simpler to conduct, safer and more satisfactory than 're-introduction' schemes, and have a much greater chance of success. Crop-edge, field-bank and sandy grassland species that were always rare in Britain ('old-rare' species), for example field cow-wheat, *Melampyrum arvense* (Kwak 1988), and always-scarce weed species like the Breckland annual *Veronica* species (*V. praecox* , *V. triphyllos* and *V. verna*) may also benefit from set-aside-related programmes. These might be used to reinforce and augment their surviving British populations, which are often already protected (Perring & Farrell 1983; Whitten 1990). It is essential that this should be done either by natural spread or with seed or appropriate propagules (Coombe 1989) from these British populations, maintaining the genetic nature and distinctiveness of each one. In many cases it may be possible to maintain such populations indefinitely in field-edge or unsprayed-headland sites which are retained for their agricultural and environmental benefits (Sotherton 1991; Wilson 1991),

2. In the re-establishment of semi-natural grassland communities

Set-aside offers excellent opportunities for the re-establishment or augmentation of some types of semi-natural grassland, but care needs to be taken in the selection and source of the species that are used, with preference always being given to re-establishment by natural spread or from seeds or other propagules taken from surviving stands of the community in the same district. The use of alien and inappropriate genotypes should be avoided; many grassland species are known to show complex patterns of variation, often with close local genetic adaptation. Differing ploidy levels also differentiate regional or local populations in some species, for example horseshoe-vetch, *Hippocrepis comosa* (Fearn 1972) and oxeye daisy, *Leucanthemum vulgare* (Whitebrook 1986). It may however be necessary to establish a framework by sowing one or more appropriate grass cultivars. Guidelines for the establishment of sandy grassland and wet grassland under set-aside rules are described in the pamphlet AR14 (MAFF 1993b), and have already been discussed. Rare or scarce species may spread naturally to such new grasslands from adjacent refuges, or may be present in sown mixtures of hay, seeds, etc. taken from surviving local stands of the community, but they should not be individually sown in, or otherwise introduced to, the new grassland except in the context of a genetically monitored conservation programme (see above). Potential problems may

arise from the genetic erosion of these surviving local populations (Ouborg, Treuren & Damme 1991; Treuren et al. 1991). The same considerations apply to insect populations, with especial care being taken to ensure that surviving local populations are not overwhelmed by genetically different, and perhaps less well adapted, introduced populations spreading from the temporarily favourable habitat provided by restored grassland on set-aside land. Programmes involving the restoration of semi-natural grassland under set-aside rules should if possible include provision for the permanent retention of viable areas of the restored grassland, in sites which will be easy to manage and will give maximum benefit, for example in field corners or as rides.

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Tables 1 and 2 Rare and Scarce plants potentially affected by set-aside conservation programmes.
Table 1.1. Rare weeds of arable land included in the* British Red Data Book *(Perring & Farrell 1983)

Species	No. of 10 km grid squares in Britain [1] Total	Recent	
Agrostemma githago	n.d.	12	post 1960
Alyssum alyssoides	6	2	post 1979
Arnoseris minima	76	0	post 1970
Bromus madritensis	4	2	post 1970
B. interruptus	65	0	post 1972
Bunium bulbocastanum	15	11	post 1960
Bupleurum rotundifolium	150	0	post 1960
Caucalis platycarpos	81	3	post 1960
Echium plantagineum	6	4	post 1960
Filago lutescens	69	12	post 1960
F. pyrmidata	96	12	post 1960
Fumaria occidentalis	15	13	post 1960
F. martinii	11	3	post 1973
Galeopsis segetum	24	1	post 1975
Galium spurium	4	1	post 1979
Gnaphalium luteoalbum	5	1	post 1980
Melampyrum arvense	40	4	post 1978
Petroselinum segetum	185	152	post 1930 [2]
Rhinanthus serotinus	68	4	post 1960
Valerianella eriocarpa	31	10	post 1960
V, rimosa	96	12	post 1960
Veronica praecox	4	4	post 1976
V, triphyllos	24	2	post 1977
V. verna	8	1	post 1979

[1] Data from Perring & Farrell (1983) (records considered to be of alien or casual status were omitted from this survey).
[2] Data from Perring & Walters (1976).

Table 1.2. Scarce weeds of arable land included in* Scarce Plants in Britain *(Stewart, Preston & Pearman 1994)

Species	No. of 10 km grid squares in Britain [1] Total	1970 onwards
Allium oleraceum	282	112
Apera spica-venti	173	99
Briza minor	73	38
Centaurea cyanus	501	127
Euphorbia platyphyllos	201	108
Fumaria bastardii	320	155
F. capreolata	350	220
F. densiflora	263	161
F. parviflora	116	48
F. purpurea	119	43
F. vaillantii	101	51
Galeopsis angustifolia	428	116
Hypochaeris glabra	229	81
Iberis amara	46	22
Myosurus minimus	322	111
Papaver argemone	733	308
P. hybridum	280	128
Ranunculus arvensis	693	221
Scandix pecten-veneris	665	131
Silene gallica	340	57
S. noctiflora	561	260
Torilis arvensis	334	82
Valerianella dentata	485	189

***Table 2. Rare plants of sandy (Sm) or chalky (Cm) field margins, open grassland (sandy, Sg; calcareous, Cg; dry, Dg; wet, Wg) and other semi-agricultural habitats, included in the* British Red Data Book *(Perring Farrell 1983)*[1]**

Species	No. of 10 km grid squares in Britain [2] Total	Recent	
Althaea hirsuta (Cm)	2	2	post 1979
Artemisia campestris (Dg)	11	3	post 1974
Centaurea calcitrapa (Cm/Sm)	109	15	post 1960
Cirsium tuberosum (Cm)	14	12	post 1970
Eryngium campestre (Dg)	17	4	post 1970
Gastridium ventricosum(Cm/Sm)	125	9	post 1980
Herniaria glabra (Sm/Sg)	15	8	post 1970
Himantoglossum hircinum (CS)	98	10	post 1970
Lythrum hyssopifolia (Wg)	38	1	post 1975
Mentha pulegium (Wg)	(many)	10	post 1960
Mibora minima (Sm)	4	3	post 1970
Ophrys fuciflora (Cg/Sg)	6	4	post 1960
O. sphegodes (Cg)	53	10	post 1970
O. simia (Cg)	8	3	post 1970
Orobanche caryophyllacea (Dg)	4	2	post 1970
O. purpurea (Dg)	19	7	post 1970
Phleum phleoides (Sg)	22	10	post 1960
Polycarpon tetraphyllum (Sm)	13	2	post 1960
Pulicaria vulgaris (WSg)	117	7	post 1976
Salvia pratensis (Cg)	28	10	post 1960
Seseli libanotis (Cg)	6	4	post 1968
Stachys germanica (Cg)	10	1	post 1979
Teucrium botrys (Cm)	11	5	post 1970
Thlaspi perfoliatum (Cm)	14	5	post 1960

[1] The list is not exhaustive but includes the majority of such species that might be considered for inclusion in set-aside related conservation programes, or be affected by them.

[2] Data from Perring & Farrell (1983) (records considered to be of alien or casual status were omitted from this survey).

The Management of Set-aside Land as Brood-rearing Habitats for Gamebirds

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Introduction

The U.K's five-year set-aside scheme began in 1988 and was designed to move land out of cereal production into various non-crop uses to reduce cereal surplus production within the European Community. However, the grey partridge *(Perdix perdix)*, a bird of open arable landscapes, is often found in cereals throughout the year, especially preferring the habitat offered by these crops for rearing their young. Populations of *P. perdix* were once a common sight on farmland but one measure of their abundance, their spring breeding density, has declined from 25 pairs km^{-2} in the early 1950s to less than five pairs by the mid 1980s (Potts 1986). The major reason for this decline has been a reduction in the rates of chick survival. To ensure high levels of chick survival young chicks need a high protein diet, particularly during the first few weeks after hatching. A high density of invertebrates from cereal crops, especially where there is an associated weed flora, supplies this need (Potts 1986; Green 1984). Most invertebrates will be eaten, but four insect groups are particularly important: plant bugs (Heteroptera, especially Miridae), leaf hoppers (Homoptera: Auchenorrhyncha), sawfly larvae (Hymenoptera, Symphyta: Tenthredinidae) and Coleoptera (especially Carabidae, Curculionidae and Chrysomelidae) (Sotherton & Moreby 1992). These four groups form the compiled guild of preferred 'chick food items'.

The change from land growing cereals, an ecosystem known under certain circumstances to be able to supply a plentiful amount of food for young gamebird chicks and many other farmland birds, into arable fallow or set-aside which is of unknown potential to provide suitable brood rearing habitat resulted in the motivation for this study. It was intended that the study would look at changes in the flora and fauna of fields in their first fallow year following harvest through to their fifth year of naturally regenerating vegetation and compare these fields to winter wheat, the main crop they replaced. However, due to changes in the Five-year Set-aside Scheme and the widespread introduction of the Rotational Set-aside Scheme in 1993, it was only possible to follow fields for three years. This paper presents the results on invertebrate densities and discusses the implications for gamebird chick survival.

Materials and methods

In late June into early July in each year, 1990-1993, fields of winter wheat and non-rotational set-aside under the Five-year Setaside Scheme were sampled on seven farms in Hampshire and Wiltshire. Over the four-year period, 66 fields of winter wheat were sampled, 33 fields of first-year set-aside, 33 of second-year and 29 of third-year set-aside.

Insects were collected using a Dietrick insect vacuum suction sampler or D-Vac (Dietrick 1961) in field headlands, approximately 3m from the crop edge. At each site, five 0.5m^2 samples were collected, with the arthropods being collected from all levels within the vegetation and from the field surface. The samples were frozen on the day of collection and later transferred to 90% alcohol. All invertebrates were counted and identified to species or family. Differences between treatments and set-aside age classes were analysed using ANOVA, after log(n+1) transformation of the data. First, second and third-year set-side were either compared separately to winter wheat or, if there was no significant difference between the age groups, all three years were pooled. If a significant difference did occur, the age classes were also compared against each other. Owing to the large number of comparisons, only significant differences at the 1% significance level or lower were accepted as indicative of treatment differences. While the field flora was sampled at all sites, these data will not be dealt with in this paper.

Results

All of the ten arthropod groups studied showed no significant differences in the numbers of individuals found on the three age classes of set-aside. All set-aside fields were therefore pooled for comparisons with winter wheat.

Sawfly larvae were the only group in which significant differences were not found between their densities in set-aside fields (pooled age classes) and fields of winter wheat (Table 1). The nine other groups were all found to differ significantly between field types.

Five groups were significantly ($P<0.01$) more numerous in the set-aside fields compared to wheat fields; namely spiders, Auchenorrhyncha, Heteroptera, Curculionidae and the compiled group of total chick food items. Four were significantly ($P<0.001$) more numerous in the wheat fields than in the set-aside, namely Chrysomelidae, Carabidae, Aphididae and Diptera .

Discussion

The most important chick food insect group for gamebird chicks are the sawfly larvae. Populations are thought to cycle through delayed density dependence (Potts 1977; Aebischer 1990) and high densities can be found in cereals in the latter part of this cycle. While no significant differences were found between treatments during the years of this study, very low densities were found (<0.2 per 0.5 m^{-2}).

The most common technique of dietary analysis is by examination of faecal pellets from chicks (Moreby 1988). Of the four arthropod groups found to be more numerous in wheat, the Diptera are a group that are difficult to detect in dietary analysis

of insect fragments in chick faecal material. They are soft bodied and large pieces of insect cuticle fail to appear in faecal samples. They are also only a very minor food item in a partridge chick's diet. While over eight times the number of aphids were found in the wheat compared to the set-aside, this level was well below the economic threshold for applying insecticides. Aphids commonly occur in the diet of chicks. However numbers found either in faecal material or during postmortems in the guts and gizzards of chicks found dead on farmland never reflect the actual density occurring in the field. Most nymphal and adult aphids will be out of reach on the upper leaves of the cereal plants. Both Coleopteran groups (leaf beetles and ground beetles) are important in the diet of gamebird chicks. However a highly significant difference was found between treatments ($P<0.001$) for both of these groups and the overall density was less than one individual per 0.5 m^{-2}.

Four arthropod groups were found to be significantly more numerous in the set-aside fields compared to the fields of winter wheat, namely the Auchenorrhyncha, Curculionidae, Heteroptera and spiders. Spiders are not a group considered to be an important component in the diet of young gamebird chicks. However, the other three groups are major constituents of the compiled guild of chickfood insects.

Auchenorrhyncha were the most numerous of all the groups, accounting for over 60% of total chick food items. However, due to the numerical dominance of this one group, a simple comparison between set-aside and wheat can be misleading for two main reasons. In rough grassland, as found on naturally regenerating set-aside, especially after the first year, Auchenorrhyncha are found 'stratified' within the vegetation layers (Payne 1981; Novotny 1992). Therefore, a number will be unavailable as food items. Also because of the size variation between nymphal instars and adults and also between species, very small hoppers will not be very important in the overall arthropod biomass needed per day. As floral diversity and microclimate also influence Auchenorrhyncha communities (Novotny 1992) further research into the effect of cultivation practices on set-aside are needed. While significantly more numerous, the numbers of Curculionidae were less than one per $0.5m^2$ in both treatments. In this study, Curculionidae would only have been a minor component in the diet. However high numbers of individuals, particularly *Sitona* spp., can be found in undersown cereals when legume mixtures are used. The difference between the treatments in numbers of Heteroptera is particularly interesting; while twice the number of individuals were found on the set-aside, the species composition was very different. Common to other studies (Moreby 1989), one species, *Calocoris norvegicus* , dominated the species composition of the cereals, while the grass-feeding Heteroptera (Stenodeminae), and other heteropteran species normally only found at the field edge, were more numerous in the set-aside.

While this paper has primarily dealt with the value of set-aside as a source of chick food insects, the whole study hopes to include the impact of set-aside on other beneficial insect groups, as well as changes in the floral composition, an area not discussed in this paper. A high density supply of insects will not help chick survival if they are unavailable and this may be the case in fields where the vegetation is dense at the base preventing easy access for small chicks as they follow their parents foraging in the brood rearing areas. A dense cover at the base can also become very wet and chicks can quickly become chilled during cold weather or the vegetation can collapse, further hindering movement. While the vegetation height varied between 10cm and 1m in all age classes of set-aside, within the first-year age-class most fields had areas of bare ground and a more open canopy structure compared to second and third year fields.

In other words, vegetation structure, canopy height and basal density can be of equal importance when defining the suitability of brood-rearing cover, not just invertebrate density and diversity.

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Table 1. Mean invertebrate density (per 0.5m²) (± one standard error) from naturally regenerating set-aside fields and winter wheat. (All set-aside age classes pooled).

Arthropod groups		No. of fields (n)		Mean density (± one S.E.)		t (dr 132)	P
Heteroptera	WW	66	3.44	±	0.37	-4.13	<0.001
	SA	95	6.04	±	0.51		
Homoptera-Auchenorrhyncha	WW	66	4.88	±	0.55	-11.29	<0.001
	SA	95	22.51	±	1.88		
Aphididae	WW	66	89.7	±	10.43	11.83	<0.001
	SA	95	11.62	±	1.37		
Hymenoptera-Tenthredinidae	WW	66	0.14	±	0.02	1.28	NS
	SA	95	0.10	±	0.01		
Coleoptera-Chrysomelidae	WW	66	0.74	±	0.07	6.47	<0.001
	SA	95	0.22	±	0.04		
Carabidae	WW	66	0. 29	±	0.03	4.54	<0001
	SA	95	0. 13	±	0.02		
Curculionidae	WW	66	0.15	±	0.07	-4.44	<0.001
	SA	95	0. 67	±	0.09		
Total Chick Food Items	WW	66	10.79	±	0.95	-9.79	<0.001
	SA	95	32.49	±	2.32		
Diptera	WW	66	82.20	±	5.95	7.86	<0.001
	SA	95	38.57	±	2.43		
Araneae	WW	66	7.24	±	0.63	-2.93	<0.01
	SA	95	10.06	±	0.72		

Insects, Plants and Succession in Set-aside

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Introduction

The agricultural landscape can be seen as a dynamic mosaic of patches, in each of which the plant and animal community undergoes a more or less orderly sequence of successional changes in the intervals between one disturbance and the next. A stable community rich in plant and animal species can develop in patches subject to mild disturbance, such as mowing or grazing, which leave intact the parts of plants at and below the soil surface. Catastrophic disturbance, such as the large-scale destruction of plant cover by ploughing or herbicide treatment, interrupts succession which must begin again from bare soil. In arable fields, annual cultivation causes disturbance which is both frequent and catastrophic, and succession never proceeds very far; frequent rejuvenation keeps the community young. Disturbed, productive habitats have increased in recent decades, with concomitant changes in the relative abundance of species of plants (Ratcliffe 1984; Hodgson 1986) and insects (Hodgson 1993; Williams 1986). In some parts of Britain a large proportion of the landscape mosaic consists of recently-disturbed patches in early stages of succession from bare soil. If patches were mapped in different colours denoting different successional ages, measured in years since the vegetation was last destroyed, land use changes could be visualised in terms of their effect on the successional age profile of the landscape.

Set-aside and several other current schemes offer opportunities to manage the pattern of successional change in the landscape (Luken 1990). In this paper I consider in general terms the nature of successional changes in plant and insect communities in the first five, ten or twenty years after ploughing, and ask what pattern of successional patches in the landscape is desirable and how set-aside might contribute to that pattern.

The nature of successional changes

Policy decisions need to be based on widely applicable generalisations. One way to draw general principles from site-specific species lists is to interpret the lists in terms of the ecological attributes of the species. This can be done for some British plant species because their ecological attributes are listed by Grime et al. 1988, but because set-aside arrived here relatively recently (Clarke 1992), long term successional pathways in set-aside in Britain must be inferred from studies of comparable non-set-aside habitats. It may seem premature to base a general picture on existing fragmentary evidence, but generalisations are needed now as a basis for current policy decisions which will structure the future landscape. No doubt some of the generalisations offered here will need substantial revision in the light of future empirical studies.

Plants

The plants present in the first year after ploughing or herbiciding will be derived from the seed rain, the seed bank or the 'bud bank' of vegetative fragments surviving in the soil. Many will be annual arable weeds (Brown 1991; Gross 1987). These ruderal annuals tend to produce numerous small seeds (Fenner 1987) that confer the mobility necessary for rapid colonisation of new sites but impose a requirement for bare soil for germination and establishment. Also present will be perennials from the bud bank, such as creeping thistle, *Cirsium arvense,* and first year plants of other perennials, particularly those with small or plumed seeds that arrived in the seed rain. The first plants to colonize sites of man-made disturbance comprise an un-coevolved assemblage of species originating from a range of different habitats (Grubb 1987). The major feature they share is the ability to arrive, through space or time, in the newly-available habitat and quickly launch propagules capable of repeating the process elsewhere. Until vegetation cover is complete, plants that are small or weak will not necessarily be shaded out by competitors, so that competitive ability is less critical than dispersability at this stage. The ruderal annuals of year one tend to be small plants (Brown & Southwood 1987) which allocate a relatively high proportion of their assimilate to seed production (Grime 1979; but see Symonides 1988) and a low proportion to underground structures (Gross 1987).

A major change occurs when the pioneer ruderals of year one give place in the second and subsequent years to monocarpic perennials, which flourish briefly, and then to polycarpic perennials (Brown 1991; Brown 1992; Brown & Southwood 1987; Davies et al. 1992; Southwood et al. 1979). The community now includes plants that are larger, both in height and in lateral spread, providing larger ecological neighbourhoods for insects (Addicott et al. 1987) and a greater allocation of biomass to underground structures (Gross 1987). Linked with this change in plant stature and in the diversity of plant structures available for exploitation by insects (Brown 1991), there must be a change in microclimate. The low, sparse vegetation of year one offers little microclimatic protection, and areas of bare soil exposed to radiative exchange with the atmosphere may suffer extremes of temperature and humidity. When tall, dense vegetation is present, the 'active surface' with its extreme microclimate is elevated to the top of the canopy, leaving microclimatically benign microhabitats on the soil and vegetation below.

Pollination and flower visitors

Associated with their small, numerous seeds, ruderal annuals typically have small, self-pollinated flowers (Brown & Burdon 1987; Grime 1979; Symonides 1988) which yield little or no nectar (Parrish & Bazzaz 1979). The perennials that succeed them have larger seeds (Harper 1977). There is an association between large seeds and large flowers (Kirk 1993 and personal communication), and between large flowers and a large nectar reward (Harder & Cruzan 1990).

Parrish & Bazzaz (1979) found a change in the spectrum of flower-visiting insects through succession after disturbance. Small, short-tongued generalist bees and hoverflies dominated the assemblage in year one of succession, but in mature prairie vegetation larger, long-tongued bees were well represented. The data of Schmidt (1976, cited in Ellenberg 1988) also show a progressive increase in the proportion of bumble bee flowers in the first ten years of succession (Fig. 1). Ostler and Harper (1987) found a correlation betweeen floristic diversity and the pollination syndrome: in communities of high diversity there were more zoophilous flowers, and relatively more flowers with characteristics associated with visitation by bees, notably blue colour and zygomorphy.

In studies of forage plants for bumble bees in Britain, we have found that these large, long-tongued bees favour perennials over annuals. The proportion of visits allocated to perennials, and particularly to monocarpic perennials, was higher than the proportion of perennials among the flowers available (Fussell & Corbet 1991, 1992; Saville 1993). A similar tendency to allocate more visits to perennials than would be expected on the basis of their proportional abundance in the habitat has been demonstrated for honeybees (Saville 1993) and butterflies (Feber 1993). The larger nectar reward per flower in perennials than in annuals may be associated with the perennials' ability to store and remobilise assimilate accumulated over many days (Fussell & Corbet 1992). Since most perennials take more than one year to flower, and ruderal annuals have small, nectar-poor flowers, first year set-aside provides little forage for bumblebees. Succeeding years bring a progressive increase in the representation of flowers with a high enough energetic reward per flower to support large endothermic pollinators like bumble bees.

Although most of the native British plant species with flowers visited by bumblebees are perennials (Fussell & Corbet 1992), a few relatively large-seeded, competitive annual species contribute to bumblebee forage. These include some that are sown as game cover, bee forage or non-food crops: borage, *Phacelia*, kale and oilseed rape (Corbet, Saville &Osborne 1994).

2.3 Insect herbivores and predators

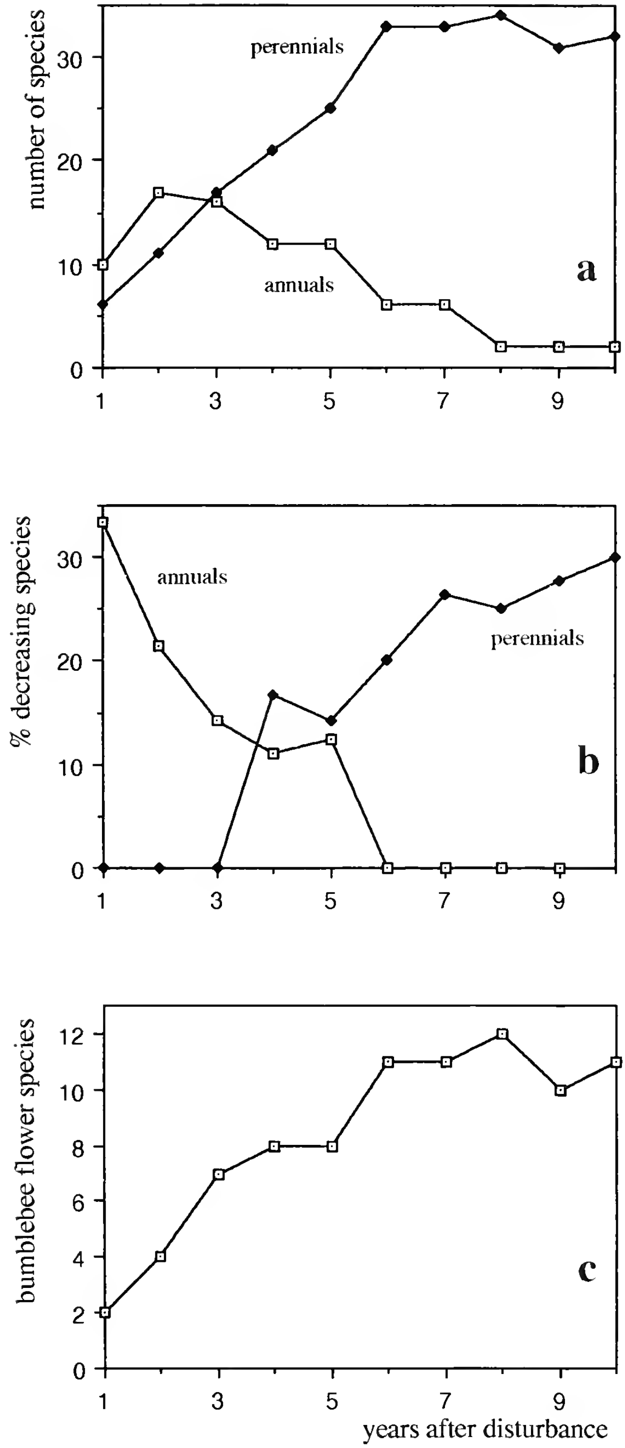
Our understanding of patterns of change in insect assemblages in the years of regeneration after cultivation rests largely on the important work of Brown and her colleagues. They found that the insect colonists in the first year after cultivation included many multivoltine species with high fecundity (r-selected species). In subsequent years univoltine species with lower fecundity (K-selected species) were increasingly represented. Niche breadth, measured in terms of numbers of host-plant species, was initially high but decreased through succession. In the first year after disturbance phytophagous insects predominated, and most of these were sap-sucking forms. In subsequent years these became relatively less important and predators increased in relative abundance (Brown & Southwood 1987, 1983; Edwards-Jones & Brown 1993). Predators are generally larger than their prey, and associated with their larger size is a longer generation time (Sabelis 1992). This, and their need for a pre-existing prey population, may contribute to their slower establishment.

Among insect predators, hoverflies and ladybirds are unusual in that they are highly mobile and multivoltine, and their larvae feed on aphids which, as r-selected sap-sucking insects, are among the first phytophagous insects to establish. Hoverflies and ladybirds may establish breeding populations earlier than many other predators, and are correspondingly valuable as pest control agents in arable crops (Wratten & Powell 1991).

Larger, less mobile predators such as ground beetles maintain populations in established perennial vegetation. In the first year after ploughing they are likely to be represented largely by recent immigrants from adjacent refuges (Sotherton 1984; Wratten & Thomas 1990). The first carabids to colonise newly-disturbed land tend to be small, mobile species capable of flight (den Boer 1990; Turin & den Boer 1988). Small, dark or reflective carabids tend to be active by day, to overwinter as adults and to show peak adult activity in June and July, whereas species with larger, paler adults tend to be nocturnal, to overwinter as larvae, and to show a peak of adult activity in August (Kegel 1990). The earliest colonists are probably the small dark forms best able to tolerate high soil surface temperatures (Kegel 1990). Perhaps the larger carabids, which presumably tend to take larger prey, establish breeding populations later in the succession.

Commonness and rarity

In general, plants of productive, disturbed habitats are species classified by Grime et al. (1988) as common and increasing in abundance in Britain, whereas in less productive, long-undisturbed habitats rare and decreasing plant species are better represented (Hodgson 1986). The proportion of rare and decreasing plant species might therefore be expected to increase through succession. Analysis of data from Schmidt (in Ellenberg 1988) showed that among perennials, the proportion of rare and decreasing species, as well as the species richness, increased progressively over the ten-year period of recolonization of heat-sterilised soil in Germany (Fig. 1). Interestingly, annuals, recognised as anomalous in this regard by Hodgson (1986), showed a converse trend; the proportion of rare and decreasing species, and the species richness, were greatest in year one, and decreased thereafter.



Legend for Figure 1

Changes in species of forbs and grasses over a ten-year period of colonization after disturbance in Germany (data from Schmidt, in Ellenberg 1988). This succession differs from that in set-aside in that it took place on heat-sterilised soil, lacking a seed bank or a bud bank, and the vegetation was unmown. a: changes in species richness of therophytes (annuals) and non-therophytes (perennials); b: percentage of species in each category classified as 'decreasing' in Grime et al. (1988); c: number of species (all of them perennials) classed as bumblebee flowers by virtue of their inclusion in a list of the top twenty species, ranked by an index of group-specific selectivity for at least one species group of bumble bees, in a national survey in Britain (Fussell & Corbet 1992). Species of Crepis, Hieracium and Solidago are included because they qualify at the generic level.

In some groups of insects, as in plants, species that are rare and decreasing have been shown to be associated with habitats that have long been undisturbed, while the species of disturbed, productive habitats are commoner and increasing. Some species of bumblebee have become extinct locally in arable regions of Britain in recent decades, and where these still persist in Kent they are associated with habitats that have not been ploughed: old meadows, sand dunes, salt marshes and shingle (Williams 1986). Similarly, the butterfly species that are rare and decreasing in Britain have larval foodplants that grow in undisturbed, nutrient-poor sites, while species that are common and increasing have larval foodplants of disturbed sites (Hodgson 1993). Other insect groups are less well documented.

Niche breadth and characteristicness

A species typically has a larger ecological niche in the absence of competitors than it has in their presence: the fundamental niche is typically greater than the realized niche (Begon et al. 1990). The early pioneers in an uncontested habitat might therefore be expected to have broader niches than the survivors of competition later in succession. A progressive narrowing of niches through succession has been demonstrated with respect to both physical and biotic aspects of plant habitat (Bazzaz 1987). The first plant colonists tolerate a wide range of soil nutrient and water status, whereas species that establish later have more specific requirements. Perhaps this reflects a change through succession in the attributes that limit establishment, from dispersability in year one to competitive ability in particular habitats in later years. With an increase in the time over which colonization has taken place, dispersability becomes less important, and as species and individuals accumulate in the community the ability to survive competition becomes more important. Parrish and Bazzaz (1979) found a progressive narrowing of the pollination niche through succession; probably both flowers and insect visitors became more specialised. A corresponding narrowing was found in the host ranges of sap-feeding insects (Brown & Southwood 1983, 1987; Edwards-Jones & Brown 1993).

An expected consequence of this progressive increase in specialisation is an increase in the extent to which a community is characteristic of the site conditions. If the pioneer colonists of a newly-disturbed site are widespread species that tolerate a wide range of different soils and microclimates (Grubb 1987), the assemblage in one newly-disturbed site is not expected to differ much in a systematic way from that in a site of similar age on different soil. In later years, the plant and insect communities become increasingly determined by, and therefore characteristic of, the local climatic and edaphic factors that determine regional vegetation types by weighting the outcome of competition. Community diversity will increase as substrate differences are increasingly represented in plant distribution patterns (Bakker 1989, p. 15). Inouye et al. (1987) showed that the floristic similarity between different sites at the same successional age was high just after disturbance but decreased progressively through succession.

Characteristic communities are not necessarily themselves species rich, for example, *Calluna* moorland may have fewer plant species per square metre than a newly bulldozed roadside verge, but they make an important contribution to diversity on a landscape and on a regional scale. The botanical and entomological interest of a community does not depend solely on species richness; it is due at least in part to this characteristicness (Bakker 1989, p. 16).

At the community level then, as at the species level, the types that are rare and decreasing are those associated with long established vegetation in undisturbed habitats.

Managing set-aside for agriculture and conservation

The potential benefits of set-aside can be assessed with respect to two features: agricultural production and the natural history interest of the landscape.

The agricultural impact of set-aside, as a crop support system, deserves attention because some of the most influential set-aside will be managed by arable farmers in an intensively arable landscape. Set-aside may defeat its own object if it causes a large increase in the yield of nearby crops, but it may have environmental and economic benefits if it reduces the agrochemical input required to maintain the current production level.

Depending on spatial scale and arrangement, the matrix of uncultivated land in the crop mosaic can act as a source of plants, insects and other animals that enter the crop. First year set-aside resembles an annual crop in terms of opportunities for plant colonisation, and its community of ruderal annuals and bud-bank perennials includes many species regarded as weeds and notable for their ability to colonise crops through space (via the seed rain) or time (via a seedbank or a bud bank of vegetative fragments in the soil). To prevent weeds from invading nearby and following crops, farmers often prevent them from seeding by mowing several times in the first season, or suppress them by growing an annual cover crop, or destroy them by ploughing or herbicide application. Mowing leaves the turf intact and allows succession to proceed, so that within perhaps three or four years the weed-rich annual flora will be replaced by perennials, most of which require less management (Baker 1974; Roebuck 1987; Smith & MacDonald 1989). On the other hand ploughing or large-scale herbicide treatment, whether or not an annual cover crop is sown, will destroy the turf so that the annual weed problem, with its high management costs, will reappear afresh year after year (Smith & MacDonald 1992).

The management required to maintain an established perennial sward is generally less than that required to counter weed problems in annually ploughed set-aside. In the first two or three years of long term set-aside, repeated mowing may be necessary to suppress weeds. If destruction of the turf by ploughing or large-scale herbiciding can be avoided, a diverse and interesting plant community may develop, with a diverse and valuable insect fauna. Natural regeneration may produce

this if there is good, species-rich perennial vegetation nearby as a colonisation source. But on nutrient-rich land remote from any source of colonising species, unassisted natural regeneration may produce rank competitive perennial weeds of low diversity. Although some of these competitive perennials provide valuable forage for honey bees and bumble bees (Fussell & Corbet 1992; Saville 1993) and support rich insect communities (Redfern 1983; Davis 1991), a more diverse plant community would have greater botanical interest. In such cases, it may be appropriate to introduce wild flower seed. Because of the risk of contaminating the local flora with alien genotypes it is essential to use authentic British seed from a reputable source, and the mixture should consist of species suitable for the soil type and the region (Akeroyd 1994). Properly managed, a wild flower seed mixture can produce a good perennial sward (Smith & MacDonald 1992).

First year set-aside resembles a crop with respect to its insect fauna, as well as its flora. The insects include small, mobile, multivoltine polyphagous herbivores such as aphids and thrips, of the type that make good pests, and these early colonists may include actual pest species, especially if crop volunteers are present. Predators are few, and nectar-rich perennial flowers are not yet present. In longer established set-aside communities the herbivores will include more K-selected and host-specific forms less likely to be pests, and the insect community will also include predators which may act as natural enemies of pests in adjacent crops.

The nectar-rich perennial flowers that come later in succession provide forage for wild bees. The contribution made by bumble bees to the pollination of field crops has not been quantified, but is likely to be substantial, at least sometimes. These large, long-tongued pollinators may be necessary for economic yield in, for example, some oilseed crops or field beans, or for seed production in, for example, red clover. A deficit of wild pollinators cannot always be remedied by bringing in hives of honey bees. On some crops effective pollination may require bees with longer tongues than honey bees, and in inclement weather the only foragers active may be large, endothermic bumble bees which have a lower temperature threshold for flight than honey bees. Thus some crops sometimes need the long-tongued endothermic bumblebees, and these in turn need a season-long succession of deep, nectar-rich flowers for the maintenance and growth of their annual colonies (Corbet et al. 1991).

The proportion of uncultivated land in the arable landscape has declined over recent decades, eroding populations of pollinators and natural enemies, to the extent that special management is recommended to augment them (Banaszak 1992; Wratten & Thomas 1990). Long term set-aside communities could help to remedy this loss. Established perennial vegetation is expected to benefit nearby crops, providing natural enemies that reduce the need for chemical pest control, and pollinators that may augment or synchronise seed yield and reduce the need to import honeybee colonies for pollination. These advantages appear relatively early in succession. There are rapid changes in the early months, so that even three or five years without disturbance can produce an insect community very different from that of the first year (Brown & Southwood 1987).

In terms of its natural history interest, first year set-aside has advantages and disadvantages. Its flora of annuals is richer and more diverse, and more likely to include rare species and any host-specific herbivorous insects associated with these, in year one than it will be in later years. Long term set-aside, on the other hand, can allow the development of perennial herbaceous vegetation with a high diversity of plants and insects, including species that are rare and decreasing in Britain.

To manage long term set-aside for annual weeds would mean sacrificing an opportunity to establish perennial vegetation, but the rare annual weeds responsible for the conservation interest of first year set-aside are not confined to this habitat. The unsprayed but annually-cultivated sites they require also occur on the 'conservation headlands' recommended by the Game Conservancy (Sotherton 1991). As well as providing food and shelter for game bird chicks and a habitat for rare annual weeds, these headlands can protect adjacent uncropped land from contamination by spray drift, and thereby accelerate the development of a mature insect and plant community, although they cannot themselves develop a perennial plant community.

Habitat diversity makes a major contribution to natural history interest at a landscape scale. Habitat diversity is increased by the presence of long-established plant communities both because these are regionally distinct and because they are rarer than they were. They are likely to reflect local features of climate and soil, in contrast to the assemblages of less habitat-specific colonists in newly-disturbed sites. Maintenance of habitat diversity in the countryside, and ultimately in nature reserves, will depend on efforts to avert or reverse the progressive decline in the age-since-disturbance of habitat patches.

Ancient meadows and woodlands centuries old are already recognised as precious and effectively irreplaceable, and many of these now receive special protection. But in much of the wider countryside, most of the established perennial herbaceous vegetation occurs in small relict patches with an age-since-disturbance of only five, ten or fifty years. Perhaps the time has come to treasure these too. As they are further eroded, the sparsity of recolonisation sources will make their replacement slower and less likely. The diversity of habitats in the countryside will be reduced, and the prospects for its eventual recovery will decline. Long-term set-aside could help to augment and strengthen this network of fragments.

One year or longer term?

The period without disturbance depends on the term of set-aside. In one year set-aside it is only a matter of months. In long-term set-aside it can be short or long, depending on management. It will be short if the farmer chooses annual sowings of a crop intended for non-food use, bee forage or game cover, or manages for annual weeds, and it will be long if he allows natural regeneration, with or without the introduction of wild flower seeds, but with occasional mowing to prevent scrub invasion. For various reasons, some farmers will choose the shortest term of set-aside available, but for the sake of both agriculture and conservation it is to be hoped that the uptake of longer-term options will be encouraged. A ten- or twenty-year set-aside community can be a more valuable component of the agricultural landscape than a one-year or annually-ploughed sward. Naturally-regenerated swards increase in value year by year. It is desirable to extend the period without disturbance as much as possible, by avoiding uncertainties that might lead farmers to destroy established vegetation unnecessarily at the end of a set-aside period, and perhaps by promoting continuity from one set-aside programme to the next.

The frequent destruction of soil and vegetation associated with arable cultivation, herbicide treatment, heavy machinery, road building and other operations have increased the area of newly-disturbed land and the associated plant and insect communities in Britain. At a time of rapid change and species loss in the wider countryside, long-term set-aside offers an opportunity to begin to rebuild some of the semi-natural communities that have suffered the most serious decline.

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1. I have been asked to respond to the wealth of interesting ideas and research presented to us today. I do so not as a manager of set-aside, but because I am currently responsible for managing the Countryside Commission's Countryside Stewardship initiative and prior to that for managing our Countryside Premium experiment. The latter set out to show that if we really had to have set-aside then there are environmental benefits that can be achieved within this framework.

2. My first thought is simply that set-aside is big. Stewart Lane told us that approximately 500,000 ha are involved. This emphasises the need to exploit whatever environmental benefits can be achieved from it. We must therefore welcome MAFF's considerable efforts in this respect although I caution that we must not expect the more adventurous environmental elements of MAFF's programme to form a significant part of the 500,000 ha .

3. In listening to the proceedings, I reflected on Countryside Premium experience. It was significant because it represented a positive step in encouraging us as conservationists to ask what can be done on land that has a relatively low environmental and recreational value - in this case land previously in intensive arable production. The evidence of this experiment after 5 years is clear. There is much that we can do, even over a relatively short time span. This is good news in relation to exploiting the potential of set-aside more widely.

4. However, the set-aside system is complicated. Further, it cannot be carefully targeted and does not directly link to the management of existing higher value habitats on the same holding. A point made in Dr Corbet's paper on bees where she emphasised that such habitats are an important part of the overall pattern.

5. The proceedings have also identified a number of environmental possibilities which could conflict unless we think carefully about where they should apply. The message I take away from today is that we should be more targeted. For example, there may be circumstances where active measures such as Terry Wells has described in sowing new diverse swards are merited. But we need clear-cut criteria to ensure that such activity does not conflict with the potential highlighted by the Game Conservancy for encouraging rare arable weeds on suitable land. More work is needed to define the circumstances in which we should select each option but today has provided some basic criteria.

6. This builds to my next point. We must set clear environmental objectives if we are to be successful and also if we are to encourage Government to continue and increase its investment in environmental improvement. We need:

i. 'Near market' research of the sort that agriculture benefitted from during its expansionary years in the 1950s, 60s and 70s. This should draw on scientific research and use trials to find the best and most effective ways of reaching a particular result. For example, much research has gone into the value of turf stripping to stimulate the seed bank on heathland. However, this is expensive and time consuming. We need to answer the question, would a simple (and much cheaper) harrowing do the same? This type of question crops up time and again in relation to managing for conservation. Another good example is the need for nutrient stripping as a preliminary step - when is it really needed and what is the easiest method for the farmer?

ii. Information in a form that is readily available and assimilated both by policy makers and busy farmers and their advisors - we must convert pure science into practical guidelines. I perceive that we have not yet reached this stage in many cases, yet it is crucial if we are to be effective advocates.

iii. Effective advisory services. Environmental improvement is still new to many farmers. There is often confusion here between land management skills which farmers possess in abundance and the need for an explanation of which of these techniques are needed for specific environmental improvements. Once land managers know what is needed they are best placed to put it into practice but they do need that initial explanation.

iv. Realism. Inevitably environmental improvement often costs money and in general the tax payer needs to provide the funding. We must therefore be realistic about the cost of objectives and what we can expect government to pay for. I was worried to hear that seeding with a wildflower mix can cost between £300 and £1000 per ha.. If we are to recommend investing taxpayers money we must find the most economical means of reaching the desired results and be sure that the public receive good value for money.

7. More widely, we must think about the relationship of set-aside to other approaches. I have already said that it is not easily targeted. If you compare it to schemes designed specifically to achieve conservation benefits such as MAFF's Environmentally Sensitive Areas or our own Countryside Stewardship, you begin to see the limitations. These environmentally based schemes allow more precise targeting and a direct linkage between existing habitats of value and the more creative conservation that we have talked about today.

8. Also, and very importantly, environmental schemes allow land managers to adopt the easiest and most appropriate management. Countryside Premium experience underlined the limitations of set-aside because of the artificial constraints it places on conservation management. For example, the best way of managing grassland to encourage species' diversity and sustain it is to use grazing livestock. Although set-aside allows grazing under very prescribed circumstances it frequently

is not a practical option and you are therefore faced with the problem of what do you do with grass cuttings and how to replicate grazing through a mowing regime.

9. I would also add a further caution. The current set-aside system, through no fault of the Ministry of Agriculture, is tending to be counterproductive for environmental objectives under certain circumstances. Both Countryside Stewardship and Environmentally Sensitive Area schemes encourage the conversion of arable land to create species rich grasslands, heathland etc under targeted circumstances. Uptake is depressed because of the way the set-aside system operates and because any arable land converted under such schemes cannot count towards the set-aside calculation. In effect, agricultural subsidies are actively working against Government funded environmental schemes. This needs to be resolved and is something that I know the Ministry of Agriculture are very conscious of.

10. Another thought that occurred to me in the light of the various opportunities highlighted today is the scope for what the current jargon calls cross-compliance. We might look to making the set-aside entitlement trigger some form of environmental farm appraisal or even to make it conditional on such an appraisal. This might then form the basis for targeting environmental improvement on set-aside land and also to introduce conditions protecting other areas of high value on the same holding.

11. Finally, we must be cautious in expecting that set-aside can solve some of our fundamental environmental concerns. There is much that it can deliver but at heart it is an agricultural supply control measure. Also, we should think ahead and look to advocating a system of agricultural support that places environmental benefits at the core of the policy not, as is currently the case, a question of building in as much as we possibly can within a framework that is not always helpful.

12. However, I will leave you with a more positive thought. The history of countryside conservation over the last 30-40 years has been one of looking inwards to protect an ever-declining and ever more threatened resource. Set-aside presages major changes in the way we support our agriculture. It has acted as a trigger for environmentalists to look outwards and start to think about creative, as well as protective conservation. In this respect at least we should be grateful for set-aside.

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Whilst the Government's longer term policy is to seek to reform the Common Agricultural Policy further to remove the need for set-aside and other artificial constraints on production, its policy in the meantime is to maximise the potential benefits of set-aside for the rural environment.

The primary purpose of set-aside under the Arable Area Payments Scheme is to reduce excess production. Therefore any measures to improve the environmental benefits of set-aside must be consistent with maintaining its effectiveness in controlling production. In practice this means that, although certain changes to the set-aside rules could improve the scope for environmental gains, the Government will only support these if they would not undermine either the effectiveness of set-aside or seriously weaken our ability to enforce the policy. For example, the EC set-aside rules prohibit all agricultural production on set-aside land (other than crops for non-food uses) for most of the year. This includes grazing. Whilst the Government accepts that grazing is the most beneficial means of managing the green cover, it has strong reservations about seeking any change to the rules to allow grazing. This is because allowing grazing on set-aside would enable farmers with livestock to reduce their area of grassland rather than their arable area. The only way to prevent this would be to introduce a system of individual arable quotas, which would be extremely bureaucratic to devise and administer.

UK Agriculture Ministers are pursuing the policy of 'greening' set-aside in three main ways:

1. In negotiations at EC level, by seeking changes to the EC rules which will make the system more flexible and offer greater scope for both short and longer term environmental gains. The UK has been successful to date in negotiating a number of amendments which should significantly improve the scope for such benefits, for example in getting agreement to allowing set-aside to be managed on a non-rotational basis (the original proposal was that all set-aside should be rotated annually) and in negotiating a special lower set-aside percentage requirement for UK farmers to encourage them to take up nonrotational set-aside. UK Ministers are currently pressing for further changes to create a link between set-aside and other schemes under which arable land is taken out of production altogether, long term (such as the Farm Woodland Premium Scheme and the new Habitat Scheme) so that farmers can count land put into these schemes against their set-aside requirement. This would encourage uptake of the environmental schemes and increase the long term environmental benefits from set-aside.

2. At national level, by putting in place a framework of national set-aside management rules which enable farmers to manage the land in ways which make sense in both environmental and agronomic terms, and to take account of local circumstances and wildlife and botanical interest on their farms. The set-aside management rules have been drawn up in consultation with a wide range of farming and environmental interests. They are under constant review and are modified in the light of experience - for example the rules on use of herbicides on set-aside were relaxed following the first year when widespread cutting and cultivation in the spring caused damage to wildlife. At all times, the Government's aim is to balance environmental and agronomic/economic considerations to ensure that the land is managed in ways which protect and enhance the environment whilst at the same time not putting UK farmers at a competitive disadvantage compared with their counterparts elsewhere in the EC.

3. Through advice and further information. Ministers place high priority on ensuring that farmers have all the information they need to be able to manage their set-aside in the most beneficial way. This need is met through scheme literature and additional written advice, both from Agriculture Departments and, very importantly, from specialist environmental organisations. In addition the Ministry of Agriculture, Fisheries and Food funds both ADAS and the Farming and Wildlife Advisory Group each year to provide free conservation advice and farm visits, and this has been increased to cater specifically for advice on set-aside. At the same time, the Ministry is carrying out a comprehensive programme of research into set-aside management, and the information from this is fed into policy as it becomes available. It also takes a close interest in relevant work being carried out by other organisations and welcomes any views and information which outside organisations have to offer.

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The Department of the Environment works closely with colleagues in MAFF towards achieving an interlocking of environmental concerns with agriculture policy. I would endorse the points made by the first two panel members: in applauding the lead which MAFF has taken, often as a lone voice in Europe, in pressing for integration of environmental concerns in the Common Agricultural Policy; in the need to persuade the EC to allow woodland and environmental schemes to count toward set-aside quotas and to allow grazing of set-aside in the light of the environmental benefits which this would achieve; and on the principle of focusing on existing wildlife habitats as the first priority the 'BEST' motto (Buffer, Extend, Support, Target) is one which I wholeheartedly support.

Beyond this, the Department has been reflecting on the results of Countryside Survey 1990, which we published in November 1993. The results have demonstrated the importance of linear features such as hedgerows, streamsides, road verges and field margins as reservoirs for biodiversity in lowland landscapes; yet the biodiversity of these features has declined. This suggests we should target linear features in policies and encourage beneficial management of these features through set-aside and other mechanisms. Farmers would be encouraged to set-aside land along linear features if the width allowed were more flexible, rather than the 20m minimum, and if there were higher payments for beneficial management.

The twenty-year habitat scheme is clearly a very important development. Environmentalists need to think what further options would be beneficial within this scheme. We should be encouraging people who have already made five years conservation investment in their land through non-rotational set-aside to build on this through the habitat scheme at the end of the five year period.

As well as schemes, we are seeing increasing emphasis on attaching conditions to payments. This is as a result of the shift away from price support towards direct payments, such as the arable area payment scheme. Conservationists need to consider what environmental conditions would be realistic and beneficial to attach to particular sorts of environmental payments. They must be able to be justified and they must be able to be monitored, otherwise the conditions attached are likely to be minimal, and not result in environmental benefits.

One condition which has been discussed at this conference is the use of wild-flower seed of native provenance in habitat recreation schemes. The Department of the Environment generally supports approaches which enable farmers and others to identify less environmentally damaging products and make informed choices. This suggests that a labelling approach may be the way forward. However, the scientific case - including the results of genetic modelling studies such as those which have been presented by Quentin Kay - needs to be much better articulated to those who advise Ministers on policy in this area, and proposals need to be practical and not over-prescriptive.

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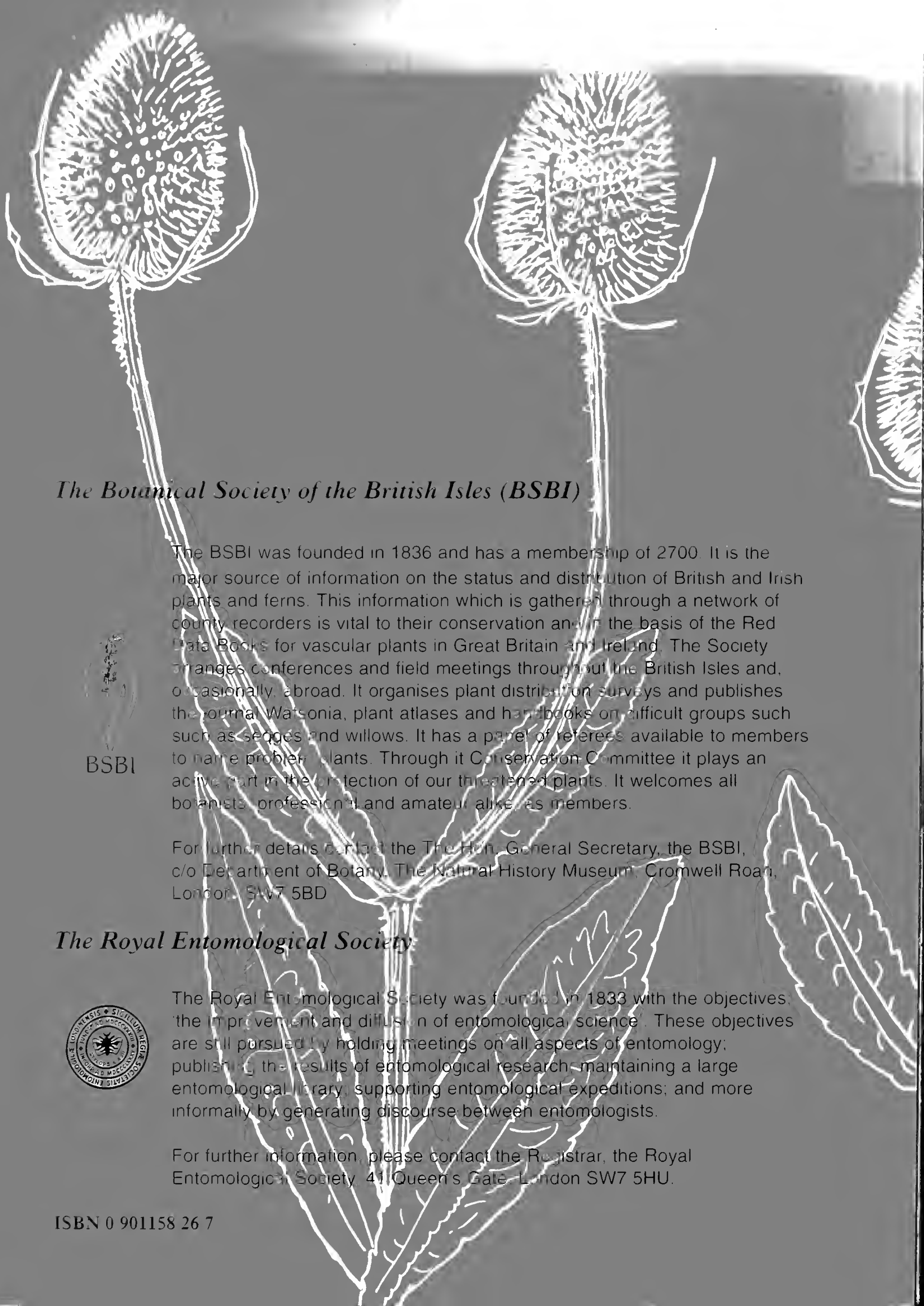

The Botanical Society of the British Isles (BSBI)

BSBI

The BSBI was founded in 1836 and has a membership of 2700. It is the major source of information on the status and distribution of British and Irish plants and ferns. This information which is gathered through a network of county recorders is vital to their conservation and is the basis of the Red Data Books for vascular plants in Great Britain and Ireland. The Society arranges conferences and field meetings throughout the British Isles and, occasionally, abroad. It organises plant distribution surveys and publishes the journal Watsonia, plant atlases and handbooks on difficult groups such such as sedges and willows. It has a panel of referees available to members to name problem plants. Through it Conservation Committee it plays an active part in the protection of our threatened plants. It welcomes all botanists, professional and amateur alike, as members.

For further details contact the The Hon. General Secretary, the BSBI, c/o Department of Botany, The Natural History Museum, Cromwell Road, London, SW7 5BD

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